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# United States Department of the Interior

## BUREAU OF RECLAMATION

Lower Colorado Regional Office

P.O. Box 61470

Boulder City, NV 89006-1470

MAR. 03 1999

IN REPLY REFER TO:

BCOO-4640

WTR-4.03

Mr. Jesse Silva  
Acting General Manager  
Imperial Irrigation District  
P.O. Box 937  
Imperial, California 92251

*W.A. - response*  
*[Signature]*

Subject: Water Conservation Studies by University of California - Davis (U.C.-Davis)

Dear Mr. Silva:

This letter is in response to a December 11, 1998, letter from then General Manager, Michael Clinton, about our meeting regarding the management of Colorado River water supplies available to California agricultural agencies. I introduced the phrase "low hanging fruit" to clarify the concept of inexpensive Imperial Irrigation District (IID) water conservation. This phrase was intended to identify water conservation measures which can achieve major water-use reductions utilizing small additional labor inputs with no resultant yield decreases or increases in soil salinity. I believe, and stated in our meeting, that studies by U.C.-Davis indicate the availability of such conservation measures to reduce water use at IID.

We have reviewed your comments in the December 11, 1998, letter and have consulted with Dr. Mark Grismer, Professor, U.C.-Davis and Dr. Khaled M. Bali, Farm Advisor Irrigation/Water Management, U.C. Cooperative Extension, Imperial County, regarding this matter.

Dr. Grismer and Dr. Bali indicated that the 1997 professional paper you described was published in England. It summarized the work accomplished by Dr. Frank Robinson, U.C. Water Scientist, while he was under contract with the Metropolitan Water District. The quote made in the December 11, 1998, letter was related to Dr. Grismer's final summary of Dr. Robinson's work regarding dropping summer irrigations of alfalfa when water-use efficiency (in terms of yield per acre-foot of water applied) is quite low. That is why you may see yield losses of alfalfa and subsequent salt-leaching required to restore satisfactory soil conditions.

Publication of results of the runoff reduction work of the past 3 years has been limited to annual progress reports and meetings attended by representatives of IID, Reclamation, and the California Department of Water Resources. These progress reports indicated that Dr. Grismer and Dr. Bali have found very little yield reduction in alfalfa and no yield loss in sudan grass over an irrigation season using the cutoff irrigation method to minimize tailwater runoff. The data also indicate that maintaining a 5 percent runoff volume eliminates any increase in soil salinity for both alfalfa and sudan grass, and that there may be an average savings of 10-12 percent of applied water for these


crops district-wide, if the runoff-reduction methods were adopted. These progress reports are enclosed for your review.

Your presentation in our meeting implied that water conservation could only occur through the relatively expensive tailwater return systems. My comment was intended to point out that farmers in IID may opt to implement less expensive conservation measures to achieve at least part of the planned conservation program.

The December 11, 1998, letter also indicated that we have been affected by anti-IID propaganda put out by junior entitlement holders. This simply is not true. Reclamation is obligated by Part 417 of Title 43, Code of Federal Regulations to see that deliveries of Colorado River water not exceed those reasonably required for beneficial use. In this regard, our goal is to be fair and objective in our administration of the Colorado River entitlements. While we listen to all sides of any particular issue, any conclusions we draw are based on our honest interpretation of the facts involved.

I look forward to our continuing effort to resolve this and other Colorado River issues.

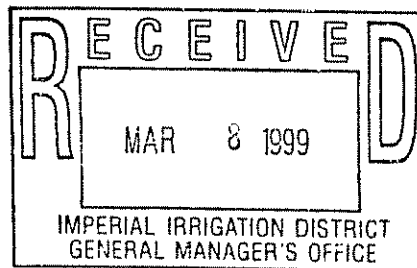
Sincerely,

ACTING FOR   
Robert W. Johnson  
Regional Director

Enclosures - progress reports

cc: Mr. Khaled Bali  
Farm Advisor  
Cooperative Extension  
1050 East Holton Road  
Holtville CA 92250-9615  
(w/o encs.)

Dr. Mark Grismer  
Professor of Agricultural Engineering  
University Of California  
Department of LAWR  
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January 3, 1997

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<b>Dean Currie- Elmore Ranch</b>	<b>Fax: (619) 344-4067</b>

**From:** Khaled Bali-UCCE Phone: 619-352-9474, Fax: 619-352-0846, E-mail:kmbali@ucdavis.edu

**Subject:** Project Advisory Meeting- Runoff Reduction Project

**Location:** University of California Desert Research & Extension Center, Conference Room. 1004 E. Holton Rd. Holtville, CA

**Date:** January 9, 1997

**Time:** 9:30 am - 12:30 pm

**Agenda:**

9:30-9:45	Introduction
9:45-10:15	Tour of research plots
10:15-11:00	Presentation of research findings.
11:00-12:00	Discussion
12:00-12:30	Lunch
12:30	Adjourn

Please note that there is an IID Water Conservation Advisory Board meeting on 1/9/97 at 1:30 pm (IID, Water Control Center, 333 Barioni Blvd, Imperial). I'll have a 10-15 min. presentation about our research project at the meeting.

Thank you in advance for your participation.

SECOND PROGRESS REPORT 12/31/96

**Irrigation and Drainage Management and Surface Runoff Reduction in Imperial Valley**

**Principal Investigators:**

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**Cooperators:**

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Bioclimatologist, Atmospheric Science, Hoagland Hall  
University of California, Davis, CA 95616  
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## Summary:

Alluvial clay soil at the University of California Desert Research and Extension Center, Holtville, CA, was cultivated and alfalfa seeds were planted in November 1995 (Field No. 2). Sudangrass was planted in April 1996 (Field No. 1). A total of 15 acres are used in this project. The area is divided into 2 fields each containing separate plantings of alfalfa and sudangrass. Each field contains 4 borders where each border is 65 ft\*1250 ft. Thirty two sampling locations were established in each field to evaluate soil moisture and soil salinity at 14 different depths (6 inches to 9 ft). Moisture contents at all sampling locations were determined by the neutron probe. The neutron probe was calibrated for each field. Soil moisture measurements were made prior to each irrigation and 2 or 3 days after each irrigation. Alfalfa and sudangrass hay samples were taken for yield determination. Summary of alfalfa and sudangrass yield data are presented in the progress report.

### Field No. 1, Crop: Sudangrass

Planting rates and dates: Sudangrass (cv. 'Piper') was planted on April 15, 1996 at the rate of 120 pounds of seed per acre.

Pest control and harvesting: According to the commercial practices of sudangrass production in Imperial Valley.

#### Irrigation dates:

1-18-96 (preirrigation)

4-16-96

5-3-96

5-24-96

6-28-96

7-23-96

8-20-96

9-17-96

#### Sudangrass was cut on:

Cut date	Average yield (tons/acre) field wt.	Average yield (tons/acre) adjusted to 10% moisture
6-17-96	2.38	2.37
8-7-96	2.25	2.24
10-10-96	2.13	2.23
Total 1996	6.76	6.84

Soil samples between 3-29-96 and 11-25-96

### Field No. 2, Crop: Alfalfa

Alfalfa (CUF 101) was planted on November 7, 1995 at a rate of 30 pounds of seed per acre.

Pest control and harvesting: According to the commercial practices of alfalfa production in Imperial Valley.

Irrigation Date(s)
11-8-95
12-4 & 12-5-95
1-22 & 1-23-96
3-19-96
4-24-96
5-17-96
6-7-96
7-3-96
8-2-96
9-10-96
11-1-96
12-20-96

Soil samples between 11-3-95 and 11-22-96

Alfalfa was cut on:

Cut date	Average yield (tons/acre) field wt.	Average yield (tons/acre) adjusted to 10% moisture
3-6-96	0.96	0.88
4-17-96	0.91	0.87
5-30-96	1.49	1.40
6-24-96	1.97	1.91
7-24-96	1.08	1.08
8-28-96	0.88	0.77



10-21-96	0.58	0.57
12-11-96	0.55	0.55
Total 1996	8.42	8.03

Alfalfa yields (alfalfa yield next to each of the 32 sampling locations, sample area is 0.91 m\*6.10 m) on:

Cut date	Average yield (Kg/ha) dry matter	Average yield (tons/acre) adjusted to 10% moisture
3-4-96	2768	1.34
4-17-96	2801	1.36
5-28-96	3822	1.85
6-24-96	3971	1.92
7-24-96	2896	1.40
8-27-96	1947	0.94
10-15-96	1845	0.89
12-9-96	1402	0.68
Total	21452	10.38

## Fields 1 and 2

Colorado River water was applied to all fields. We evaluated the irrigation efficiency of each field and for each irrigation by taking advance, recession, and flow rate measurements for all borders. Infiltration rates were evaluated for each irrigation using the advance function. A total of 32 9-ft neutron probe access tubes were installed in each field (eight neutron probe access tubes were installed in each border) to characterize soil moisture distribution in the field. Moisture measurements were taken at depths of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 6.0, 7.0, 8.0, and 9.0 ft prior to and two or three days following each irrigation. Gravimetric soil moisture samples were taken in the 0-6" depth range because the neutron scattering technique does not accurately estimate soil moisture content near the surface. Evapotranspiration during and for the two or three days following irrigations were obtained from CIMIS weather station No. 87 and were added to the difference in soil moisture prior to and following each irrigation. A total of 32 10-ft observation wells were installed in each field. Water samples from each well were taken for salinity and Cl analysis of the shallow groundwater. Soil samples from the 32 locations in each field were taken at various depths to evaluate soil salinity.

4-45

Post-It* Fax Note	7671	Date	6/19/98	# of pages	9
To	John Eckhardt	From	Khaled Bales		
Co/Dept.	TTD	Co.			
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Fax #	339-9356	Fax #			

## WATER: ECONOMICS, MANAGEMENT AND DEMAND

Edited by

**Melvyn Kay**

Silsoe College, Cranfield University, UK

**Tom Franks**

University of Bradford, UK

and

**Laurence Smith**

Wye College, University of London, UK

International Commission on Irrigation & Drainage  
Proceedings of the 18th European Regional Conference  
"Water - An economic good?"  
held in Oxford, UK, September '97.



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## AVAILABILITY OF COLORADO RIVER WATER FOR TRANSFER IN SOUTHERN CALIFORNIA

K. M. BALI and R. A. GONZALEZ

University of California Desert Research and Extension Center, Holtville, CA, USA

### Abstract

Colorado River water is the only available source of irrigation and drinking water in the Imperial Valley. As much as 345,373 ha-m (2.8 million ac-ft) of Colorado River water are used every year to irrigate more than 202,342 ha (500,000 acres) of land in the Imperial Valley. The recently proposed water transfer draft between Imperial Irrigation District and the San Diego County Water Authority calls for transfer of up to 49,337 ha-m (400,000 ac-ft) annually of Imperial Valley's allotment of Colorado River water. This study was conducted to evaluate the potential availability of water for transfer and the economic value of conserved water from two on-farm water conservation measures; 1) implementation of tailwater return systems and 2) implementation of pressurized irrigation systems. Implementation of tailwater return systems is limited to field crops grown on heavy clay soils and implementation of low-volume irrigation systems is only feasible on specific vegetable crops. The implementation of tailwater return systems will reduce surface runoff from the current Valley-wide average of 16.8% (of delivered water) to approximately 5% and may yield a maximum potential savings of approximately 24,454 ha-m (198,253 ac-ft) of water. The implementation of low-volume pressurized irrigation systems may yield a maximum potential savings of approximately 12,237 ha-m (99,209 ac-ft) of water. The use of low-volume irrigation systems requires high capital investment and significant changes in cultural practices. It also yields higher value of conserved water as compared to tailwater recovery systems. Costs associated with decline in yield and increase in soil salinity should be considered in determining the economic value of water.

Keyword: Irrigation management, water availability, water conservation, water transfer.

### 1 Introduction

Water is a limited resource in California. Water demands among agricultural and

*Water: Economics, Management and Demand*. Edited by Melvyn Kay, Tom Franks and Laurence Smith. Published in 1997 by E & FN Spon. ISBN 0 419 21840 8.

urban users in California require strategies for water transfer and management that are based on practical water conservation practices. Water transfer and marketing is playing a major role in water resources management in Southern California. Water transfers from agricultural to urban regions in California have been used as a partial solution for water shortages in the state through implementation of the state water bank during the drought period of 1987-92.

In 1989, the Imperial Irrigation District (IID) and the Metropolitan Water District (MWD) of Southern California signed a long-term agreement to transfer 13,075 ha-m (106,000 ac-ft) of water to MWD annually for 35 years. In exchange for water, MWD is providing funds for water conservation projects in the Imperial Valley. The price of transferred water is about \$811 per ha-m (\$100 per ac-ft, 1989 cost basis). The annual payment from MWD to Imperial is about \$350 million over the 35-year period of the contract. Most of the conserved water came from district-level conservation projects such as building new reservoirs and from on-farm water conservation projects.

In 1996, the IID and the San Diego County Water Authority (SDCWA) started negotiating another water transfer agreement. The recently proposed water transfer draft between IID and SDCWA calls for transfer of up to 49,339 ha-m (400,000 ac-ft) annually of Imperial Valley's allotment of Colorado River water [1]. Water available for transfer must be conserved water from on-farm water conservation programs and district-level structural conservation projects. Most of water available for transfer may come from on-farm water conservation projects. This study was conducted to evaluate the potential availability of water for transfer and the economic value of conserved water from two practical on-farm water conservation measures; 1) implementation of tailwater return systems and 2) implementation of pressurized irrigation systems. This study considers only the above conservation measures and does not consider other on-farm or district-level conservation measures that might be implemented nor does it include the possibility of a reduction in farmable land due to urbanization or land fallowing. These additional measures are expected to yield additional water savings.

## 2 Location and history

The Imperial Valley is located about 193 km (120 miles) east of San Diego, CA in the Northwestern Sonoran Desert. The Colorado River water was diverted to the Valley at the turn of the twentieth century. Colorado River water is diverted to the Valley through the All American Canal. Approximately 75% of California's agricultural water entitlement of Colorado River water is used in the Imperial Valley, the other 25% is used in Bard, Palo Verde, and Coachella Valleys in the southeastern desert area of California. The Imperial Valley has the largest irrigation delivery systems in Southern California and its agriculture contributes about one billion dollars in gross income to the California economy [2].

### 3 Irrigation practices

The Colorado River is the lifeblood of the low desert of Southern California. It is the only available source of irrigation and drinking water in the Imperial Valley. As much as 345,375 ha-m (2.8 million ac-ft) of Colorado River water are used every year to irrigate more than 202,342 ha (500,000 acres) of land in the Imperial Valley. The cost of water in the Valley is \$97.29 per ha-m (\$12 per ac-ft) in addition to a water availability charge of \$12.36 per ha per year (\$5 per acre per year). Surface irrigation, the primary method for irrigation in the Imperial Valley, is used on more than 95% of the irrigated land. Drip irrigation is used on less than 5% of the irrigated area and mostly on vegetable crops. Field crops are grown on 80% of irrigated land [2]. Surface and subsurface drainage water from irrigated fields enters the Salton Sea which serves as a drainage sink for the Imperial and Coachella Valleys (formed in 1905). The Salton Sea continues to exist because of the drainage water from agriculture in Imperial and Coachella Valleys as well as flow of agricultural drainage and untreated and partially treated sewage from the Mexicali Valley. Several water quality issues exist in the Imperial Valley because of surface and subsurface drainage and its impact on the Sea, for which water conservation and transfer play a major role.

### 4 Water conservation

#### 4.1 Implementation of tailwater return systems

In 1985, IID initiated a demonstration project to evaluate the potential use of tailwater recovery systems (TRS) in the Valley [3]. The estimated cost of a runoff recovery system designed by IID was about \$1,186 per ha (\$480 per acre, 1990 cost basis). The annualized pump back system cost was approximately \$173 per ha (\$70 per acre, 1990 cost basis) which includes capital and operation/maintenance costs. The impacts of such systems on soil salinity were not conclusive [3]. Changes in soil salinity ranged from 29% higher to 38% lower when compared to conditions prior to the construction of these systems. Increases in soil salinity may result in decline in crop yield and result in an increase in the economic value of conserved water. The economic value of conserved water is defined here as the costs associated with conserving a unit of water (ha-m or ac-ft) and includes capital, operational, and maintenance costs in addition to costs related to decline in yield as a result of certain water conservation measure. Based on data available to date, the costs associated with decline in crop yield are negligible with such a system. The effect of expected increase in soil salinity and potential reduction in crop yield on water value is also considered here.

Tailwater recovery systems yielded a 12% potential savings of delivered water [3]. The average agricultural tailwater in the Valley is approximately 16.8% of applied water [4]. The average depth of applied water for each of the three major field crops [5] in the Imperial Valley and the average acreage [2] are shown in Table 1. The weighted average depth of applied water for these major field is 1.67 ha-m/ha per year (5.48 ac-ft/ac per year). Therefore, tailwater recovery systems yield an average of 0.200 ha-m/ha per year (0.6576 ac-ft/ac per year) with an average value of conserved

water at \$864.87 per ha-m (\$106.45 per ac-ft, 1990 cost basis). Summary of the value of water saved and the amount of water that can be saved are shown in Table 1. All values are adjusted to account for inflation and reported in 1996 cost basis (\$1 in 1990 is equivalent to approximately \$1.23 in 1996). These values are based on the assumption that costs associated with increase in soil salinity and decline in crop yield are negligible. The effect of salinity on crop yield and the economic value of conserved water is discussed in section 4.2.

Table 1. Average acreage, water use, and value of conserved water for major field crops in the Imperial Valley (1990-1995).

Crop	Area (acre)	Avg. water use (ft)	Vol. of cons. water (ac-ft)	Water value* (1996) (\$ per ac-ft)
Alfalfa	181,134	6.3	141,285	110.38
Sudangrass	63,106	4.8	36,349	149.48
Wheat	57,275	3.0	20,619	239.17
Total	301,515	5.48**	198,253	131.22**

\*Based on negligible changes in soil salinity

\*\* Weighted average

Another method was recently proposed to reduce or eliminate surface runoff water in heavy clay soil [6]. The surface runoff reduction (SRR) method is based on a relatively simple technique that predicts the cutoff time necessary to minimize or eliminate runoff and to improve water use efficiency. While the method is applicable for all soils, it works best in heavy clay soils. The method is a combination of a volume balance model [7] and a two-point measurement method [8]. The objective in heavy clay soil is to have enough water to fill soil cracks with little or no runoff. Preliminary results of research conducted at the University of California Desert Research and Extension Center in the Imperial Valley indicate that the method is suitable for clay soils, however, an increase in soil salinity and a reduction in yield were observed at the tail end of the field. While there are no capital costs associated with this method, there is the additional time needed for irrigation planning and management and other costs associated with decline in yield as a result of salinity buildup in soil. The advantage of this method is that it can be implemented in relatively short period of time in response to short-term water needs by urban regions in Southern California.

The implementation of tailwater return systems is limited to field crops grown on heavy clay soils. Approximately 60-70% soils in the Imperial Valley are classified as heavy clay soil [9]. The IID estimates that approximately 40% of heavier soils will benefit from tailwater return systems [2]. We estimate that at most 121,406 ha (300,000 acres) will benefit from the implementation of tailwater return systems and surface runoff reduction method. Our estimates is based on the average acreage of alfalfa, sudangrass, and wheat between 1990 and 1995 [2].

The implementation of tailwater return systems will reduce surface runoff from the current Valley-wide average of 16.8% (of delivered water) to approximately 4.8% and yield a maximum potential savings of approximately 24,454 ha-m (198,253 ac-ft) of water. Because of the large acreage of alfalfa in the Valley and its relatively high consumptive water use, water saving from alfalfa is the highest and the value of

conserved water is the least when increases in soil salinity are negligible. In addition, implementation of the above methods will reduce surface elevation of the Salton Sea and minimize the amount of agricultural chemicals in runoff water.

#### 4.2 Effect of salinity on crop yield and water value

We consider here the effect of increases in soil salinity on crop yield and economic value of conserved water for the three major field crops in the Imperial Valley. The effect of soil salinity on crop relative yield can be estimated with following equation [10]:

$$Y = 100 - b(EC_e - a) \quad (1)$$

where  $Y$  is the relative yield for soil salinities exceeding the threshold of any given crop,  $a$  is threshold value (dS/m) or the maximum root salinity at which no reduction in yield is observed,  $b$  is % reduction in yield per dS/m above the salinity threshold value, and  $EC_e$  is the average root zone salinity. Soil salinity levels below the threshold values will not affect crop yield or quality. The values of  $a$  and  $b$  are; 2.0 dS/m and 7.3 % per dS/m for alfalfa, 2.8 dS/m and 4.3 % per dS/m for sudangrass, and 5.9 dS/m and 3.8 % per dS/m for wheat [10].

The value of conserved water increases as the average root zone salinity exceeds a threshold level for a given crop. The value of conserved water can be estimated with the following equation:

$$V = (C/W) \{ (100 - Y) * Z / 100 \} \quad (2)$$

where  $V$  is the value of conserved water (\$ per ac-ft),  $C$  is cost of water conservation measure (\$ per ac),  $W$  is the amount of conserved water (ac-ft/ac),  $Y$  is as defined above,  $Z$  is the crop value (\$ per ac) when the average root zone salinity below the threshold level. Crop values for the three major field crops in the Imperial Valley (obtained from the 1995 Imperial County Agricultural Crop and Livestock report and adjusted for inflation to reflect 1996 cost basis, \$1 in 1995 is equivalent to approximately \$1.038 in 1996) are shown in table 2. Fig 1. shows the economic value of conserved water at various salinity levels for major field crops in the Imperial Valley.

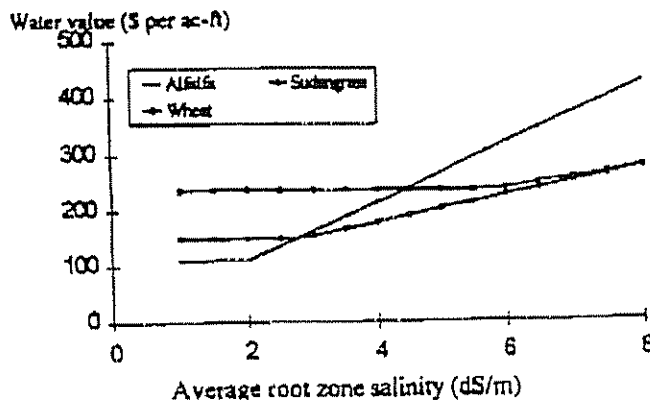




Table 2. Average yield and crop value for major field crops in the Imperial Valley.

Crop	Yield (tons per ac)	Value per unit* (1996) (\$ per ton)	Value per ac* (1996) (\$ per ac)
Alfalfa	7.94	90.79	720.87
Sudangrass	6.50	88.23	573.50
Wheat	2.75	176.46	485.27

\* 1996 value basis

#### 4.3 Implementation of low-volume irrigation systems

The implementation of low-volume irrigation systems is only feasible on specific vegetable crops (approximately 20% of the irrigated area). The value of the potential decline in yield and increase in soil salinity should be considered. We consider here the additional amount of water needed for leaching to maintain soil salinity at levels optimum for crop production. The amount of water used by vegetable crops varies widely. The amount of water saved from implementation of low-volume irrigation systems on vegetable crops will vary since vegetable crops are grown at various times during the year. The average acreage of major vegetable crops grown in the Imperial Valley and their current consumptive water use [11] are shown in Table 3. These crops represent more than 80% of vegetable crops in the Valley during the period between 1990 and 1995.

The cost of conversion to drip irrigation system varies considerably from one location to another and depends on many variable related to crop, soil, climate, type of system, and water source. Here, we use the average cost of a typical drip irrigation system in the Valley of \$1532 per ha (\$620 per acre, 1996 cost basis) [11] which includes costs of the system and labor. We assume the system will last for three years or three growing season. The average seasonal cost associate with removal of drip tape, chemical for maintenance, and additional costs is \$193 per season [11].

Drip irrigation is relatively new in the Imperial Valley. Crop water use figures for drip irrigated crops in the Imperial Valley are not available and vary widely depending on system type (surface or subsurface), soil type, growing period (planting and harvesting dates), and location (variability in reference evapotranspiration). Several studies have shown that while crop water use under subsurface may be lower than under furrow or sprinkler irrigation, crop water use is virtually the same under surface drip and furrow systems [12]. Therefore, we considered the above variables and estimated the minimum, maximum, and average crop water use under drip irrigation for each of the major vegetable crops in the Valley independently from crop coefficients and reference evapotranspiration [13, 14, &15] during the growing season. The additional water needed for leaching was calculated and added to crop water use [10]. The predicted water use and amount of water that can be saved from converting to drip irrigation systems are shown in table 3. These figures include a leaching fraction of 15% or a minimum of 0.10 m (4 in) of water for salt leaching after each season. The frequency of leaching depends on crop type, salinity of irrigation water, and salinity level in the root zone. Our assumptions are based on the leaching requirements of the most sensitive vegetable crop in the region. Leaching could be done after each season using a sprinkler irrigation system or after several

seasons using flood irrigation. To maintain salt balance, we estimated that a minimum of 1 ac-ft/ac is needed after three seasons of continuous planting. These values are included in the predicted water use figures in table 3.

Table 3. Average acreage, current water use and predicted water use figures for major vegetable crops in the Imperial Valley (1990-1995).

vegetable crops in the Imperial valley (1990-1992)					
Crop	Area (Acres)	Water use (ac-ft/ac) Current*	Avg. Range		Avg. Cons. water (ac-ft/ac) (ac-ft)
			Predicted**		
Head lettuce	28,376	3.00	1.70 (1.1-2.3)	1.30	36,889
Cantaloupes	20,377	3.75	3.15 (2.7-3.6)	0.60	12,226
Carrots	13,993	3.75	2.10 (1.4-2.8)	1.65	23,088
Onions	10,924	4.50	3.10 (2.4-3.8)	1.40	15,294
Broccoli	7,808	3.50	2.00 (1.4-2.6)	1.50	11,712
Total	81,478				99,209

\*Surface irrigation, \*\*Drip irrigation

We estimate that approximately 40,469 ha (100,000 acres) will benefit from the implementation of low-volume irrigation systems. In this analysis, we consider the number of acres that could be converted to drip irrigation (vegetable crops). The implementation of low-volume pressurized irrigation systems will save approximately 12,237 ha-m (99,209 ac-ft) at an average value of \$2,661 per ha-m (\$328.24 per ac-ft, 1996 cost basis). The amount of water that can be saved and the value of conserved water are shown in table 4.

Table 4. Volume and value of conserved water for major vegetable crops in the Imperial Valley (1990-1995).

Crop	Vol. of cons. water (ac-ft)	Water value (1996) (\$ per ac-ft)
Head lettuce	36,889	307.44
Cantaloupes	12,226	666.11
Carrots	23,088	242.22
Onions	15,294	285.48
Broccoli	11,712	266.47
Total	99,209	328.24*

\* Weighted average

In general, the value of saved water using drip irrigation systems is at least 250% higher than the value of conserved water from TRS. However, the value of conserved water from TRS increases as soil salinity increases due to decline in yield. The use of low-volume irrigation systems requires high capital investment and significant changes in cultural practices. It also yields higher value of conserved water as compared to tailwater recovery systems.

### 5 Conclusions

The implementation of tailwater return systems will reduce surface runoff from the current Valley-wide average of 16.8% (of delivered water) to approximately 5% and

yield a potential savings of approximately 24,454 ha-m (198,253 ac-ft) of water. The implementation of low-volume pressurized irrigation systems will save approximately 12,237 ha-m (99,209 ac-ft). The use of low-volume irrigation systems requires high capital investment and significant changes in cultural practices. It also yields higher value of conserved water as compared to tailwater recovery systems.

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## **Irrigation and Drainage Management and Surface Runoff Reduction in Imperial Valley**

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**Duration of the Project:** 3 years (September 1, 1995 - December 31, 1998)



**Fawzi Karajeh, Ph.D.**  
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## Executive Summary:

Colorado River water is the only source of irrigation and drinking water in the Imperial Valley, however it contains more salts than any other surface irrigation source in California. As much as 2.8 million acre-feet of Colorado River water are used every year to irrigate more than 500,000 acres of lands in the Imperial Valley. Surface and subsurface drainage water enters the Salton Sea which serves as a drainage sink for the Imperial and Coachella Valleys since its formation in 1905. The Salton Sea continues to exist because of the drainage water from agriculture in Imperial and Coachella Valleys as well as flow of agricultural drainage and untreated and partially treated sewage from the Mexicali Valley. Because of drainage and its impact on the Sea, several water quality issues exist in the Imperial Valley for which water conservation plays a role.

The Salton Sea water surface elevation has recently (May 1995) reached the highest level in record since 1920. The overall peak elevation for 1994 exceeds that of 1992 by approximately 0.7-0.8 ft. Surface runoff and subsurface drainage water from agricultural lands in Imperial Valley contribute to this increase in elevation. Currently, the salinity of the Sea is nearly 46,000 ppm or approximately 130% the salinity of the Pacific Ocean. Our objective is to conduct a research and demonstration project that will improve irrigation efficiency, reduce surface runoff, utilize the shallow saline water table for new and improved irrigation and drainage management practices, determine crop coefficients for two common field crops (alfalfa and sudangrass) and increase utilization of CIMIS for irrigation scheduling. We are also planning to publish a Handbook about the best management practices for reducing surface and subsurface drainage water. All educational activities will be conducted in cooperation with the Imperial Irrigation District (IID) and the California Department of Water Resources (DWR).

More than 15% of the delivered irrigation water in Imperial Valley becomes tailwater runoff. This water transports significant amounts of chemicals that eventually reach the Salton Sea. Efficient irrigation practices are needed to minimize runoff and to reduce the amount of chemicals in runoff water. This study will focus on development and demonstration of a new method to predict irrigation cutoff time from pre-determined soil moisture status of the clay soil of interest. Issues related to salinity, irrigation management, and water quality will also be addressed in this project. Since soil salinity and water management are affected by water table depth, a major part of this study will be to quantify the effect of water table control on soil salinity, water infiltration rates, and irrigation efficiency. To observe cumulative aspects of reduced water table depth on soil salinity and consumptive water use, this study will be conducted for three years.

Our work will focus on field crops, specifically alfalfa and sudangrass. Field crops account for almost 80% of the 500,000 acres of irrigated land in the Imperial Valley and alfalfa and sudangrass rank 2nd and 7th, respectively, in terms of total production (1993 Imperial County Agricultural Crop and Livestock report). These two major field crops were grown on more than 236,000 acres of irrigated lands in Imperial Valley in 1993.

## **Educational Elements:**

A user-friendly computer program considering practical applications of the BMP's described in Handbook will be developed by the principle investigators. The program will include educational elements about water quality as well as practical applications of surface runoff reduction methods that will be developed as part of this research project at the University of California Desert Research and Extension Center.

Other educational forums of this project include:

1. Irrigation Management and Surface Runoff Conference.
2. Field Days (three).
3. UC Publication Best Management Practices Handbook,  
"BMPs for Irrigation Management and Surface Runoff Reduction in Clay soils".
4. Computer program and worksheets to improve irrigation efficiency in clay soils

A comprehensive guide to irrigation and drainage management and BMPs for runoff reduction in the Imperial Valley will be developed by the principal investigators with contributions from other scientists. This Guide will be completed by December 31 1998 and will be available to growers and the general public. Several field days and seminars will be conducted during the project. Field days, seminars and shortcourses will be conducted by the principal investigators and invited speakers from University of California, Department of Water Resources , Imperial Irrigation District, and farmers. Findings from this research and demonstration project will be published in local, statewide, and national agricultural magazines such as California Agriculture, CA/AZ Farm Press, California Farm Bureau's Ag. Alert, and scientific journals.

## **Introduction:**

Temporal (during the season) variability of infiltration is often the cause of excessive runoff and poor irrigation efficiency in heavy clay soils. The ability to predict changes in infiltration characteristics is the key to improve application efficiency (AE) and distribution uniformity (DU) of surface irrigation systems (Jensen, 1980). Simulation models of surface irrigation systems often use the same infiltration function throughout the season. The ability to predict surface irrigation system performance is directly influenced by temporal and spatial soil variability.

Several investigators have considered different aspects of infiltration variability in irrigated fields. Izadi and Wallender (1985) quantified the effect of soil variability on infiltration characteristics. Linderman and Stegman (1971) showed that infiltration characteristics varied during the season. Vieira et al. (1981) studied the spatial variability of field-measured infiltration rates. Wallender (1986) developed a volume balance furrow irrigation model with spatially varying infiltration characteristics and Bali and Wallender (1987) studied the combined effect of soil variability and intake opportunity time on furrow irrigation systems performance. They also studied field-measured and simulated furrow irrigation system performance under spatially and temporally varied infiltration function parameters. Cracking of soils was most likely the source of variability between simulated and observed field advance rates. Bali et al. (1994)



showed that spatial variability of infiltration in heavy clay soils did not have significant impacts on surface irrigation system performance as compared to temporal variability. Grismer and Tod (1994) tested a field procedure to estimate irrigation time in cracking clay soils using a volume balance method.

Heavy clay soils represents more than 60% of the nearly 200,000 ha of irrigated land in the Imperial Valley, CA. Approximately 16% of the irrigation water is lost to surface runoff due to the limited infiltration in clay soils. Water penetration is usually limited to free water flow into cracks and infiltration parameters vary widely between irrigations over the season. This research will be conducted to study the effect of changes in water table elevation on surface irrigation system performance and surface runoff in a cracking clay soil. The specific objectives of this research and demonstration project are:

- 1- Determine the best management practices (BMPs) for surface runoff reduction in heavy clay soils of the Imperial Valley.
- 2- Determine the effect of water table control on irrigation management and consumptive use of water by alfalfa and sudangrass (including crop coefficients for alfalfa and sudangrass).
- 3- Determine the contribution of shallow saline water tables to crop evapotranspiration in heavy clay soils.
- 4- Develop a relatively simple approach to predict irrigation cutoff time from pre-determined soil moisture measurements.
- 5- Develop a user-friendly computer program and irrigation management spreadsheets for efficient irrigation management practices. These tools include: the use of CIMIS for irrigation scheduling, prediction of crop water requirements for alfalfa and sudangrass, and prediction of seasonal changes in AE, DU, and surface runoff.
- 6- Conduct field days, demonstrations, seminars, and publish results in both popular and scientific media.

This research and demonstration project will be conducted at the University of California Desert Research and Extension Center (UCDREC) near Holtville, CA, a site having soils that are typical of the major acreage of Imperial Valley Soils.

## **Procedures**

A total of 15 acres will be used in this research project. The area will be divided into 2 fields each containing separate plantings of alfalfa and sudangrass. Each field will be further divided into 4 borders where each border is 65 ft\*1250 ft.

### **Field No. 1, Crop: Sudangrass**

Sudangrass growing seasons (March-October, 1996, 1997, and 1998)

Planting rates and dates: Sudangrass (cv. 'Piper') will be planted in March 1996, March 1997, and March 1998 at a rate of 120 pounds of seed per acre.

Pest control and harvesting: According to the commercial practices of sudangrass production in Imperial Valley.

Water table control: The water table will be lowered to at least 15 ft below land surface in the upper 500 ft of the middle two borders as compared to a normal water table depth of 4-5 ft below land surface in the proposed field.

## **Field No. 2, Crop: Alfalfa**

Alfalfa growing season (October 1995 - October 1998)

Planting rates and dates: Alfalfa (CUF 101) will be planted in October 1995 at a rate of 30 pounds of seed per acre.

Pest control and harvesting: According to the commercial practices of alfalfa production in Imperial Valley.

Water table control: Tile drains will be blocked in the upper 500 ft of all borders in this field so as to encourage maximum crop use of the shallow water table. Preliminary studies indicate that the water table rises to within 3-4 ft of the land surface in blocked drain fields.

## **Fields 1 and 2**

Colorado River water will be applied to all fields. We will evaluate the irrigation efficiency of each field by taking advance, recession, runoff and flow rate measurements for all borders. Initial infiltration rates will be measured during each irrigation as described by Bali and Wallender (1987) and soil samples will be collected at various depths after each irrigation. The samples will be analyzed for Na, Ca, Mg, K, Cl, and trace elements such as Se and B. Soil moisture distribution in each border will be evaluated using the neutron probe. A total of 32 9-ft neutron probe access tubes will be installed in each field (eight neutron probe access tubes will be installed in each border) to characterize soil moisture distribution in the field. Moisture measurements will be taken at depths of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 6.0, 7.0, 8.0, and 9.0 ft prior to and two days following each irrigation. Gravimetric soil moisture samples will be taken in the 0-15 cm depth range because the neutron scattering technique does not accurately estimate soil moisture content near the surface. Evapotranspiration estimates during and two days following irrigations will be obtained from a nearby CIMIS weather station (station no. 87) and will be added to the difference in soil moisture prior to and following each irrigation. Soil samples will be regularly taken at various depths to evaluate soil salinity. A total of 32 10-ft observation wells will be installed in each field. Water samples from each well will be taken for chemical analysis of the shallow groundwater throughout the project.

Irrigation scheduling will be based on CIMIS data and on soil moisture measurements as described by Snyder and Bali (1992). Surface runoff and drainage water samples will be taken for chemical analysis. The samples will be analyzed for Na, Mg, Ca, K, Cl, EC, and TDS.

Alfalfa and sudangrass yield will be determined for each cutting and standard statistical analyses will be used to evaluate the effectiveness of different water table elevations. Statistical methods of evaluation will involve the use of ANOVA and time series analysis software.

All irrigations will be started from the south end of the field and advance time will be recorded every 50 ft along each border. The commonly used Kostiakov and modified Kostiakov equations

$$z=kt^a \text{ and} \quad (1)$$

$$z=kt^a+ct, \text{ respectively,} \quad (2)$$

where  $z$  is the depth of water infiltrated,  $t$  is the intake opportunity time,  $k$  and  $a$  are empirical constants, and  $c$  is the steady infiltration rate, will be used to simulate border irrigation performance in a volume-balance model (Elliott and Walker, 1982). Infiltration function parameters  $k$  and  $a$  will be obtained for each irrigation and each border from advance data using a power advance function of the form (Walker and Skogerboe, 1987)

$$X=pt^r \quad (3)$$

where  $X$  is the advance distance (m),  $t$  is the advance time (min), and  $p$  and  $r$  are fitted parameters. The above power advance function will be used to predict the infiltration function parameters  $k$  and  $a$  of the Kostiakov equation using the two-point method (Elliott and Walker, 1982). Simulated and field-measured irrigation performance characteristics of border irrigation (AE, DU, surface runoff, deep percolation, and depth infiltrated) will be evaluated for all irrigations using spatially averaged and temporally variable infiltration characteristics.

Advance rates from all irrigations over the season will be correlated with soil moisture content before the corresponding irrigation and actual volume of applied water. An empirical function describing the relationship between moisture content before irrigation and advance rate and cutoff time will be developed for various flow rates and soil moisture depletion levels (see appendix A for details).

The empirical function for eliminating surface runoff will be tested for soil moisture depletion levels between 2.5 and 6 inches over the entire root zone. Statistical methods of evaluation will involve the use of the time series analysis procedures (Davis, 1973).

#### Summary of work plans:

- \* sudangrass planted for three successive years on the same ground (Field No. 1)
- \* Sudangrass planted in March and harvested until October
- \* alfalfa planted in October 1995 (duration of crop: 3 years, Field No. 2)
- \* water table lowered from 5 to 15 ft in the upper 500 ft of field No. 1 (sudangrass)
- \* tile drains blocked in the upper 500 ft of field No. 2 (alfalfa)
- \* hay yield at each cutting (weighing bales in field)
- \* infiltration rates and irrigation performance characteristics will be evaluated for each treatment throughout the experiment
- \* soil samples for chemical analysis will be collected throughout the experiment.
- \* drainage flow rate will be monitored
- \* surface runoff will be evaluated and water samples will be collected on a regular basis.

- \* water table elevation and salinity will be monitored on a regular basis (32 observation wells in each field)
- \* consumptive water use is determined between irrigations
- \* ANOVA and time series analysis methods used to determine statistical parameters of concern in the experiments.

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Proposed Budget:

	1995-96	1996-97	1997-98	Total
Staff research assistant	\$26,700	\$27,600	\$28,600	
Field Assistants/helpers	\$3,600	\$3,900	\$4,300	
Seed, fertilizer, pesticide, sprinkler, etc. (alfalfa and sudangrass)	\$4,500	\$2,400	\$2,400	
Irrigation and soil sampling supplies	\$500	\$500	\$500	
Pump for drainage water removal and plumbing supplies	\$4,000	\$400	\$400	
Permanent Equipment auger, computer, printer software, and computer supplies for data collections and field days	\$3,500	\$600	\$600	
Field days, short courses expenses and BMP publication cost	\$700	\$700	\$1500	
Reagents and chemical supplies/analysis	\$600	\$600	\$600	
Radiation use authorizations and training on Neutron probe	\$350	\$400	\$400	
Travel To present findings and for travel to/from UCD.	\$1,200	\$1,200	\$1,900	
<b>Subtotal</b>	<b>\$45,650</b>	<b>\$38,300</b>	<b>\$41,200</b>	<b>\$124,150</b>
<b>Indirect cost (10%)</b>	<b>\$4,565</b>	<b>\$3,830</b>	<b>\$4,120</b>	<b>\$12,415</b>
<b>Total</b>	<b>\$50,215</b>	<b>\$42,130</b>	<b>\$45,320</b>	<b>\$137,665</b>

<b>Inkind support:</b>		1995-96	1996-97	1997-98	1998-99
Total					
University of California					
Personnel and time commitment					
Bali	20%	\$10,700	\$10,700	\$10,700	
Grismer	10%	\$8,300	\$8,300	\$8,300	
SRA (M. Jimenez)	50%	\$20,337	\$20,337	\$20,337	
UCDREC (land & labor)		\$11,250	\$11,250	\$11,250	
Imperial County					
County Funds		\$5,592	\$5,592	\$5,592	
Total inkind support		\$56,179	\$56,179	\$56,179	157,287

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## APPENDIX A:

Irrigation scheduling can be based on a relatively simple technique that predicts the cutoff time necessary to minimize runoff and to improve water use efficiency. While the method is applicable for all soils it works best in heavy clay soils. The method is a combination of a volume balance model and a two-point measurement method.

The main objective in heavy clay soils is to have enough water to fill cracks with little or no runoff. The cutoff time can be calculated for a given border using a volume balance model where the total volume of water applied equals the surface storage and the subsurface storage. At any time ( $t_x$ ) the volume applied,  $V$ , is

$$V=Q*t_x$$

Where  $Q$  is the inflow rate in cubic feet per second (cfs) and  $t_x$  is the time in minutes. The surface storage ( $SY$ ) equals the product of the average depth of water and the area covered by water

$$SY=\sigma_y*d*w*l_x$$

where  $\sigma_y$  is the surface shape factor (0.6-0.8),  $d$  is the depth of water at the water inlet in feet,  $w$  is the width of border in feet, and  $l_x$  is the advance distance at time  $t_x$ .

The subsurface storage ( $SZ$ ) equals the product of the average depth stored and the area covered by water. Earlier in the irrigation, soil cracks dominate the process of infiltration and the volume of the subsurface storage is essentially the volume of cracks. Thus,

$$SZ=z*w*l_x$$

where  $z$  is the average depth stored below the soil surface in feet, and  $w$  and  $l_x$  are as defined earlier. The total volume,  $V$ , is the sum of the surface storage and subsurface storage:

$$V=SY+SZ$$

The average depth stored below the surface can be found at any time,  $t_x$ ,

$$Q*t_x = (\sigma_y * d * w * l_x) + (z * w * l_x)$$

$$z = \frac{(Q*t_x - \sigma_y * d * w * l_x)}{(w * l_x)}$$

when z is known, the time of cutoff,  $t_{co}$ , can be determined to minimize runoff. The total volume applied ( $Q*t_{co}$ ) equals to the volume stored:

$$Q*t_{co} = w * L * z$$

$$t_{co} = \frac{(w * L * z)}{Q}$$

where L is the total length of the border.

The following information is needed to determine cutoff time:

- 1- Border length and width in feet.
- 2- Average flow rate in cfs.
- 3- Depth of the water at the inlet (or soil roughness).
- 4- One or two points of water advance with time along the border.

#### **Proposed Approach to determine cutoff time:**

Our objective is to predict the average depth of infiltration, z, from soil moisture depletion using

$$D = (\theta_{max} - \theta)R$$

where D is soil moisture depletion in feet,  $\theta_{max}$  is volumetric soil moisture content at saturation,  $\theta$  is the average volumetric soil moisture content of the root zone before the irrigation event, and R is root zone depth in feet.

Our results have shown that z is directly related to D and R, or in other words  $z = f(D, R)$ . However, at this time, we will assume that z is a function of D only ( $z = f(D)$ ). We will evaluate this empirical function from measured values of D and z at several soil moisture depletion levels. Once the function is determined, the cutoff time ( $t_{co}$ ) can be determined in advance using the following equation

$$t_{co} = \frac{w * L * f(D)}{Q}$$

This equation allows us to predict the time of cutoff before the irrigation event. The advance function can also be predicted. The advance function can be described by

$$x = pt^r$$

where t is the time since the start of advance and p and r are fitted parameters (  $r \approx 1$  for near linear advance,  $r=1$  for linear advance). The average depth stored below the soil surface, z, can be calculated from

$$z = \frac{Q * t_{co}}{W * L}$$

For a linear advance ( $x=pt$ ), the slope of advance, p equals  $l_x/t_x$  and when  $t_x$  equals  $t_{co}$ ,  $l_x$  is the distance of advance at the time of cutoff, and therefore p can be evaluated from

$$p = \frac{Q}{(\sigma_y * d * W) + (f(D) * W)}$$

Predicted and measured values of p will be compared. The above approach is valid when the soil's bulk density is constant over a wide range of moisture content. However, in clay soils, bulk density is directly affected by moisture content. We will account for this fact by using a bulk density function which is dependent on moisture content.

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## DEPARTMENT OF WATER RESOURCES

1416 NINTH STREET, P.O. BOX 942836  
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(916) 653-5791



January 28, 1997

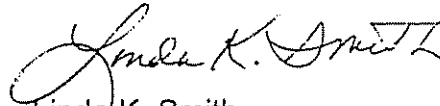
Mr. John J. Buckley  
Imperial Irrigation District  
333 East Barioni Blvd.  
Imperial, California 95660

RE: DWR Agreement No. 165574

Enclosed for your records is one fully executed copy of the agreement stated above.

If you have any questions regarding the services to be performed under this agreement, please contact Fawzi Karajeh at (916) 327-1828. If you have any questions regarding the processing of this agreement, please feel free to call me at (916) 653-7201.

Sincerely,

  
Linda K. Smith  
Contracts Analyst

Enclosure

*Original - file  
1/30 CC: Thorne  
McLullough  
O'Halloran  
Grunbaum / JH*

Receivable Agreement No. 165574  
between  
The California Department of Water Resources  
and  
The United States Bureau of Reclamation, Lower Colorado River  
and  
The Imperial Irrigation District  
for  
Cooperation to Fund  
Irrigation and Drainage Management and Surface Runoff Reduction in the Imperial  
Valley Project  
to be Conducted  
by  
The Regents of the University of California

THIS AGREEMENT, entered into this 15th day of June 1995 by and between CALIFORNIA DEPARTMENT OF WATER RESOURCES (hereinafter called the "State"), The United States Bureau of Reclamation, Lower Colorado River (hereinafter called the "USBR"), and The Imperial Irrigation District (hereinafter called the "IID").

WHEREAS, Irrigation and Drainage Management and Surface Runoff Reduction in Imperial Valley (hereinafter called the "project") was called for by the State and prepared by the Regents of the University of California (hereinafter called the "contractor") and later reviewed and discussed by the above parties and revised by the Regents.

**PURPOSE OF THE PROJECT**

This project will focus on the development and demonstration of a new method to predict irrigation cutoff time from predetermined soil moisture status of the clay soil of interest. Issues related to salinity, irrigation management, and water quality will also be addressed in the project. Since soil salinity and water management are affected by water table depth, a major part of this study will be to quantify the effect of water table control on soil salinity. The study will be conducted over three years in order to observe cumulative consumptive water use. The purpose of this project will be achieved according to the Contract B-80560 Section Two.

**TERMS AND COSTS OF THE CONTRACT**

The term of this contract is from June 15, 1995 through December 31, 1998. The cost of the project, upon the availability of fund from all funding participants, shall not exceed \$137,597 and is to be paid:

\$61,300 the state share from fiscal year 1994/1995 budget  
\$61,300 the USBR share, received by the State from USBR ("Assistance Agreement No. 6-FC-30-00720, is attached.")  
\$14,997 the IID share, received by the State from IID

If any party reduces its funding level, the State will reduce total cost of the project by that

amount. The contract shall not become effective until approved by the Department of General Services.

Payments from USBR and IID should be made available to the State immediately upon a written notice by the State after the contract approval by the Department of General Services.

#### RESPONSIBILITIES

The State will manage the project under Contract B-80560 with the Regents of the University of California (the contractor). The contractor will submit to the State an original of five progress reports and the final report with copies to both USBR and the State according to the schedule stated in the Contract B-80560 Section Seven.

#### AGREEMENT

The cooperators agree the state will enter into an agreement with the contractor to initiate field work, and to take advantage of the coming irrigation season. It is provided that the scope of this work be expanded to additional task(s) to cover on farm field data collection and analyses. In such event, upon mutual agreement of all parties, the Contractor agreed to undertake such work per Contract No. B-80560. Additional study task(s) may be done through an amendment to this contract or through a new one. The additional cost of such new task(s) will be negotiated at that time with the Contractor.

It is also agreed that either party shall be free to use, release, make a presentation, or publish all or part of the data and results of the study or the reports. In doing so, each party must give credit for the contribution of the other.


#### ATTACHMENTS

Exhibit A, the USBR Assistance Agreement No. 6-FC-30-00720, is attached and hereby made a part of this agreement.

Exhibit B, The Standard Clauses, are attached and hereby made a part of this agreement.

The parties hereto have executed this Agreement as of the day and year first written.

THE CALIFORNIA DEPARTMENT OF WATER RESOURCES

By   
Raymond D. Hart, Chief  
Division of Local Assistance

Date 12/26/96

Approved as to legal form  
and sufficiency

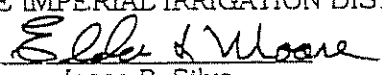
Asst. Chief Counsel, DWR

THE UNITED STATES BUREAU OF RECLAMATION, LOWER COLORADO RIVER

By   
Gary Bryant  
Area Manager

Date 12/16/96

THE IMPERIAL IRRIGATION DISTRICT

By   
Jesse P. Silva  
Water Manager

Date 11-15-96

amount. The contract shall not become effective until approved by the Department of General Services.

Payments from USBR and IID should be made available to the State immediately upon a written notice by the State after the contract approval by the Department of General Services.

#### RESPONSIBILITIES

The State will manage the project under Contract B-80560 with the Regents of the University of California (the contractor). The contractor will submit to the State an original of five progress reports and the final report with copies to both USBR and the State according to the schedule stated in the Contract B-80560 Section Seven.

#### AGREEMENT

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The parties hereto have executed this Agreement as of the day and year first written.

THE CALIFORNIA DEPARTMENT OF WATER RESOURCES

By *Raymond D. Hart*  
Raymond D. Hart, Chief  
Division of Local Assistance

Date 12/26/96

Approved as to legal form  
and sufficiency:

*W. J. [Signature]*  
Asst. Chief Counsel, DWR

THE UNITED STATES BUREAU OF RECLAMATION, LOWER COLORADO RIVER

By *Gary Bryant*  
Gary Bryant  
Area Manager

Date 12/10/96

FORM	POLICY	SUBJECT
Department of General Services		
APPROVED		
JAN 9 1997		
BY <u><i>[Signature]</i></u>		
Asst. Chief Counsel		

THE IMPERIAL IRRIGATION DISTRICT

By *Jesse P. Silva*  
Jesse P. Silva  
Water Manager

Date 11-15-96



UNITED STATES  
DEPARTMENT OF THE INTERIOR  
BUREAU OF RECLAMATION  
ASSISTANCE AGREEMENT

Exhibit A  
Page 1

DUPLICATE ORIGINAL

<p>1. AGREEMENT NO. 6-FC-30-00720</p>	<p>2. TYPE OF AGREEMENT <input type="checkbox"/> Grant <input checked="" type="checkbox"/> Cooperative Agreement</p>	<p>3. REQUISITION NUMBER 96-300-460047</p>
<p>4. ISSUED BY                      CODE <u>LC-4640</u> Bureau of Reclamation Lower Colorado Region P.O. Box 61470 Boulder City NV 89006-1470</p>		<p>5. RECIPIENT Department of Water Resources Water Conservation Office 1020 Ninth Street, Third Floor Attention: Fawzi Karajeh Sacramento CA 95814</p>
<p>6. NAME, ADDRESS, AND PHONE NO. OF ASSISTANCE REPRESENTATIVE  Steve Jones LC-4640 Bureau of Reclamation P.O. Box 61470 Boulder City NV 89006 702-293-8186</p>		<p>7. NAME, ADDRESS, AND PHONE NO. OF RECIPIENT'S PROJECT MANAGER Department of Water Resources Water Conservation Office 1020 Ninth Street, Third Floor Attention: Fawzi Karajeh Sacramento CA 95814 916-327-1828</p>
<p>8. PROGRAM STATUTORY AUTHORITY  Water Research and Development Act of 1978</p>		<p>9. CLASS OF RECIPIENT State Government</p>
<p>10. EFFECTIVE DATE See block 16 below</p>		<p>11. COMPLETION DATE December 31, 1998</p>
<p>12. TOTAL AMOUNT OF AGREEMENT <u>\$61,300.00</u>  AMOUNT OF FUNDS OBLIGATED <u>\$ 61,300.00</u></p>		<p>13. ACCOUNTING AND APPROPRIATION DATA  3X0-1316-6000-500-10-0-0      3040460</p>
<p>14. PROJECT TITLE This study will focus on the development and demonstration of a new method to predict irrigation cutoff time from pre-determined soil moisture status of the clay soil of interest. Issues related to salinity, irrigation management, and water quality will also be addressed in the project including crop coefficients for alfalfa and sudan grass. Since soil salinity and water management are effected by water table depth, a major part of this study will be to quantify the effects of water table control on soil salinity, water infiltration rates, and irrigation efficiency. The study will be conducted over three years in order to observe cumulative aspects of reduced water table depth in soil salinity and consumptive water use.</p>		
<p>15. Acceptance of this Assistance Agreement in accordance with the terms and conditions contained herein is hereby made on behalf of  <u>California Department of Water Resources</u> NAME OF RECIPIENT BY <u>Raymond D. Hart</u> <u>4/19/96</u> SIGNATURE                      DATE  <u>Raymond D. Hart</u> TYPED NAME  TITLE <u>Chief, Division of Local Assistance</u>  Telephone No. (916) 327-1828</p>		<p>16. Acceptance of this Assistance Agreement in accordance with the terms and conditions contained herein is hereby made on behalf of the United States of America, Bureau of Reclamation.  BY <u>Jayne Harkins</u> <u>9/26/96</u> SIGNATURE                      DATE  <u>Jayne Harkins</u> TYPED NAME  TITLE <u>Grants and Cooperative Agreements Officer</u>  Telephone No. (702) 293-8190</p>

COOPERATIVE AGREEMENT  
NO. 6-FC-30-00720  
BETWEEN  
BUREAU OF RECLAMATION  
AND  
THE STATE OF CALIFORNIA, DEPARTMENT OF WATER RESOURCES  
TO PROVIDE  
IRRIGATION AND DRAINAGE MANAGEMENT IN SURFACE  
WATER RUN-OFF REDUCTION IN THE IMPERIAL VALLEY

This Agreement between the DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION, herein referred to as "Reclamation," and the STATE OF CALIFORNIA, DEPARTMENT OF WATER RESOURCES herein referred to as "CADWR," is entered into pursuant to the Water Research and Development Act of 1978

A. BACKGROUND

The purpose of this agreement is to provide support for a study to be conducted by the CADWR and the University of California, focusing on the development and demonstration of a new method to predict irrigation cutoff time from pre-determined soil moisture status of the clay soil of interest. Issues related to salinity, irrigation management, and water quality will also be addressed in the project including crop coefficients for alfalfa and sudan grass. Since soil salinity and water management are effected by water table depth, a major part of this study will be to quantify the effects of water table control on soil salinity, water infiltration rates, and irrigation efficiency. The study will be conducted over three years in order to observe cumulative aspects of reduced water table depth in soil salinity

B. OBJECTIVE AND BENEFIT

The objective of this program is to conduct a research and demonstration project to improve irrigation efficiency and reduce surface run-off in the Imperial Valley.

C. RESPONSIBILITIES OF THE PARTIES

CADWR will:

1. Conduct a research and demonstration project.
2. Comply with the General Provisions for Agreements which are attached and made a part hereof.
3. Comply with all laws and ordinances in pursuing the work to be done under this Agreement.
4. Contribute funds in an amount not to exceed 50 % of the total program costs.

Reclamation will:

1. Contribute funds in an amount not to exceed 50 % of the total program costs.
2. Provide a project manager to oversee the progress of the project and to act as liaison with CADWR.

D. PERFORMANCE SCHEDULE AND DELIVERABLES

This Agreement will be effective from the date of award through December 31, 1998, contingent on the availability of funds and success of the program.

E. BUDGET

Contingent upon availability of funds, and upon further definition of the data requirements and specific tasks, the total funds to be provided by Reclamation pursuant to this Agreement shall not exceed \$61,300.

If CADWR does not utilize the entire amount of funding (\$61,300), the balance will be refunded on a pro rata basis to Reclamation. Liability on the part of Reclamation for any payment is contingent upon appropriation and allocation of funds.

F. BILLINGS

Prior to payment by Reclamation, CADWR will submit a completed Standard Form 270 (SF-270), Request for Advance or Reimbursement to the Assistance Representative. The request for Advance or Reimbursement should be sent to Reclamation 25 days prior to initiating the work program activities, to allow adequate time for review and processing. The advance will be in the amount as follows:

- (1) \$61,300 following execution of this agreement;

CADWR shall furnish an original SF-270 to the following address:

Director  
Colorado River Water and Power Management Office  
Bureau of Reclamation  
Attention: LC-4640  
P.O. Box 61470  
Boulder City NV 89006-1470

G. MODIFICATION

The parties to this Agreement may mutually amend and/or extend this Agreement and any such amendment or extension shall be confirmed in writing prior to performance or change.

#### H. TERMINATION

A party may terminate this Agreement upon 30 days' written notice to the other parties. Reclamation shall pay for all work which, in the exercise of due diligence, the recipient is unable to cancel prior to the effective date of termination. Payments made under this agreement, including payments under this article, shall not exceed the ceiling amount elsewhere specified in the agreement.

#### I. LIABILITY

Reclamation and CADWR agree that they will assume liability, pursuant to Federal, and California law, respectively, for the negligence of their employees or agents in carrying out the provisions of the work. Reclamation and CADWR, to the extent permitted by law, agree to hold the other parties harmless in regard to any damages caused by their respective employees or agents in performing work financed under this agreement. Any liability of the United States shall be limited to that allowed under the Federal Tort Claims Act and the CADWR State Tort Claims Act.

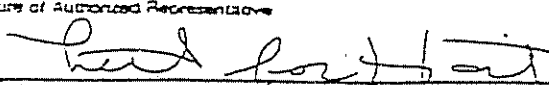
J. OFFICE OF MANAGEMENT AND BUDGET (OMB) CIRCULARS. The following OMB Circulars are incorporated by reference into this agreement:

1. A-87, "Cost Principles for State and Local Governments."
2. A-102, "Grants and Cooperative Agreements with State and Local Governments."
3. A-128, "Audit Requirements for State and Local Governments."

# APPLICATION FOR FEDERAL ASSISTANCE

Contract NO. 100374, EXN1012 A, Page 5

OMB Approval No. 0348-0043

<b>1. DATE SUBMITTED.</b> 		<b>Applicant Identifier:</b> N/A																													
<b>2. TYPE OF SUBMISSION:</b> Application <input type="checkbox"/> Construction <input checked="" type="checkbox"/> Non-Construction		<b>3. DATE RECEIVED BY STATE</b> N/A																													
<b>4. DATE RECEIVED BY FEDERAL AGENCY</b> 		<b>State Application Identifier</b> N/A																													
<b>5. APPLICANT INFORMATION:</b> 		<b>Federal Identifier</b> 																													
<b>Legal Name:</b> Department of Water Resources		<b>Organizational Unit:</b> Division of Local Assistance																													
<b>Address (give city, county, state, and zip code):</b> 1020 Ninth Street, 3rd Floor Sacramento, California 95814		<b>Name and telephone number of the person to be contacted on matters involving this application (give area code):</b> Fawzi Karajeh (916) 327-1818																													
<b>6. EMPLOYER IDENTIFICATION NUMBER (EIN):</b> 52-1692634		<b>7. TYPE OF APPLICANT (enter appropriate letter in box):</b> <input checked="" type="checkbox"/> A. State <input type="checkbox"/> B. County <input type="checkbox"/> C. Municipal <input type="checkbox"/> D. Township <input type="checkbox"/> E. Interstate <input type="checkbox"/> F. Intermunicipal <input type="checkbox"/> G. Special District <input type="checkbox"/> H. Independent School Dist. <input type="checkbox"/> I. State Controlled Institution of Higher Learning <input type="checkbox"/> J. Private University <input type="checkbox"/> K. Indian Tribe <input type="checkbox"/> L. Individual <input type="checkbox"/> M. Profit Organization <input type="checkbox"/> N. Other (Specify):																													
<b>8. TYPE OF APPLICATION:</b> <input checked="" type="checkbox"/> New <input type="checkbox"/> Continuation <input type="checkbox"/> Revision If Revision, enter appropriate letter(s) in box(es): <input type="checkbox"/> A. Increase Award <input type="checkbox"/> B. Decrease Award <input type="checkbox"/> C. Increase Duration <input type="checkbox"/> D. Decrease Duration Other (specify):		<b>9. NAME OF FEDERAL AGENCY:</b> U. S. Bureau of Reclamation																													
<b>10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER:</b> TITLE: AREAS AFFECTED BY PROJECT (cities, counties, states, etc.): Nationwide		<b>11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:</b> Conduct study and demonstration project to improve irrigation efficiency and reduce surface runoff in the Imperial Valley																													
<b>12. PROPOSED PROJECT:</b> Start Date: 6/15/95 Ending Date: 12/31/98		<b>13. CONGRESSIONAL DISTRICTS OF:</b> a. Applicant: 3rd b. Project: 52nd																													
<b>14. ESTIMATED FUNDING:</b> <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width:20%;">a. Federal</td> <td style="width:10%;">\$</td> <td style="width:40%;">61,300</td> <td style="width:10%;">00</td> </tr> <tr> <td>b. Applicant</td> <td>\$</td> <td></td> <td>00</td> </tr> <tr> <td>c. State</td> <td>\$</td> <td>61,300</td> <td>00</td> </tr> <tr> <td>d. Local</td> <td>\$</td> <td>14,997</td> <td>00</td> </tr> <tr> <td>e. Other</td> <td>\$</td> <td>160,109</td> <td>00</td> </tr> <tr> <td>f. Program Income</td> <td>\$</td> <td></td> <td>00</td> </tr> <tr> <td>g. TOTAL</td> <td>\$</td> <td>268,109.</td> <td>00</td> </tr> </table>		a. Federal	\$	61,300	00	b. Applicant	\$		00	c. State	\$	61,300	00	d. Local	\$	14,997	00	e. Other	\$	160,109	00	f. Program Income	\$		00	g. TOTAL	\$	268,109.	00	<b>15. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?</b> a. YES THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON: DATE _____ b. NO <input checked="" type="checkbox"/> PROGRAM IS NOT COVERED BY E.O. 12372 <input type="checkbox"/> OR PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW	
a. Federal	\$	61,300	00																												
b. Applicant	\$		00																												
c. State	\$	61,300	00																												
d. Local	\$	14,997	00																												
e. Other	\$	160,109	00																												
f. Program Income	\$		00																												
g. TOTAL	\$	268,109.	00																												
<b>16. IS THE APPLICANT DELINQUENT ON ANY FEDERAL DEBT?</b> <input type="checkbox"/> Yes If Yes, attach an explanation. <input checked="" type="checkbox"/> No		<b>17. TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL DATA IN THIS APPLICATION/PREAPPLICATION ARE TRUE AND CORRECT, THE DOCUMENT HAS BEEN DULY AUTHORIZED BY THE GOVERNING BODY OF THE APPLICANT AND THE APPLICANT WILL COMPLY WITH THE ATTACHED ASSURANCES IF THE ASSISTANCE IS AWARDED.</b> 																													
<b>18. Printed Name of Authorized Representative:</b> Raymond D. Hart		<b>19. Title:</b> Chief, Division of Local Assistance																													
<b>20. Signature of Authorized Representative:</b> 		<b>21. Telephone number:</b> (916) 327-1646																													
<b>22. Date Signed:</b> 4/19/96																															

Authorized for Local Reproduction

Standard Form 124 (REV. 1-83)  
Prescribed by GSA Circular 2-102

Page 1

## STATEMENT OF WORK

### General Provision:

#### Section One: Purpose of Contract:

This study will focus on the development and demonstration of a new method to predict irrigation cutoff time from pre-determined soil moisture status of the clay soil of interest. Issues related to salinity, irrigation management, and water quality will also be addressed in the project including crop coefficients for alfalfa and sudangrass. Since soil salinity and water management are effected by water table depth, a major part of this study will be to quantify the effects of water table control on soil salinity, water infiltration rates, and irrigation efficiency. The study will be conducted over three years in order to observe cumulative aspects of reduced water table depth on soil salinity and consumptive water use.

## Section Two: Objectives:

Conduct a research and demonstration project with the objectives to:

1. improve irrigation efficiency,
2. reduce surface runoff,
3. determine the contribution of shallow saline water tables to crop evapotranspiration in heavy clay soils,
4. determine the effect of water table control on irrigation management and consumptive use of water by alfalfa and sudan grass (including crop coefficients for alfalfa and sudan grass),
5. develop a relatively simple approach to predict irrigation cutoff time from pre-determined soil moisture measurements,
6. increase the utilization of CIMIS for irrigation scheduling,
7. develop a user-friendly computer program and irrigation management spreadsheets for efficient irrigation management practices,
8. publish a handbook about the best management practices for reducing surface and subsurface drainage water, and
9. conduct field days, demonstrations, seminars, and publish results in both popular and scientific media.

## Section Three: Workplan

- sudan grass planted for three successive years on the same ground (Field No. 1)
- sudan grass planted in March and harvested in October
- alfalfa planted in October 1995 (duration of crop: 3 years, Field No. 2)
- water table lowered from 5 to 15 feet in upper 500 feet of Field No. 1 (sudan grass)
- tile drains blocked in upper 500 feet of Field No. 2 (alfalfa)
- hay yield at each cutting (weighing bales in field)

- infiltration rates and irrigation performance characteristics will be evaluated for each treatment throughout the experiment
- soil samples for chemical analysis will be collected throughout the experiment
- drainage flow rate will be monitored
- surface runoff will be evaluated and water samples will be collected on a regular basis
- water table elevation and salinity will be monitored on a regular basis (32 observation wells in each field)
- consumptive water use is determined between irrigations
- ANOVA and time series analysis methods will be used to determine statistical parameters of concern in the experiments



Rev. 1/22/96

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## GENERAL PROVISIONS

### 1. Policy

The following Office of Management and Budget (OMB) Circulars, as applicable, and as implemented by 43 CFR Part 12, are incorporated by reference and made a part of this agreement. Failure of a recipient to comply with any provision may be the basis for withholding payments for proper charges made by the recipient and for termination of support.

a. Agreements with colleges and universities shall be in accordance with the following circulars:

Circular A-88, Revised December 5, 1979, "Indirect Cost Rates, Audit, and Audit Followup at Educational Institutions"

Circular A-21, Revised July 26, 1993, "Cost Principles For Educational Institutions"

Circular A-110, Revised December 29, 1993, "Uniform Requirements for Grants and Agreements with Institutions of Higher Education, Hospitals, and Other Nonprofit Organizations"

Circular A-133, March 16, 1990, "Audits of Institutions of Higher Learning and Other Nonprofit Institutions"

b. Agreements with State and local governments shall be in accordance with the provisions of the following circulars:

Circular A-87, May 17, 1995, "Cost Principles for State and Local Governments"

Circular A-102, Revised October 14, 1994, "Uniform Administrative Requirements for Grants and Cooperative Agreements with State and Local Governments"

Circular A-128, April 12, 1985, "Single Audits of State and Local Governments"

c. Agreements made with nonprofit organizations shall be in accordance with the following circulars and provisions:

Circular A-110, Revised December 29, 1993, "Uniform Requirements for Grants and Agreements With Institutions of Higher Education, Hospitals, and Other Nonprofit Organizations"

Circular A-122, June 27, 1980, and amended March 17, 1981, April 27, 1984, May 17, 1987, and October 6, 1995, "Cost Principles for Nonprofit Organizations"

Circular A-133, March 16, 1990, "Audits of Institutions of Higher Learning and Other Nonprofit Institutions"

d. All agreements with organizations other than those indicated above shall be in accordance with the basic principles of OMB Circular A-110, and cost principles shall be in accordance with Part 31 of the Federal Acquisition Regulations, Subpart 31.2 entitled, "Contracts with Commercial Organizations."

### 2. Officials Not to Benefit

No member or delegate to Congress, Resident Commissioner, or Federal or State official, shall be admitted to any share or part of this agreement, or to any

benefit that may arise therefrom.

### 3. Covenant Against Contingent Fees

The recipient warrants that no person or agency has been employed or retained to solicit or secure this agreement upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide offices established and maintained by the recipient for the purpose of securing agreements or business. For breach or violation of this warranty, the Government shall have the right to annul this agreement without liability or, in its discretion, to deduct from the agreement amount, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

### 4. Equal Opportunity

During the performance of this agreement, the recipient agrees to comply with the Civil Rights Act of 1964, 42 USC 200a et seq., as amended and Executive Order No. 11246 as amended by Executive Order No. 12086 and as supplemented in Department of Labor Regulations (41 CFR Part 60).

### 5. Disabled Veterans and Veterans of the Vietnam Era

a. The recipient will not discriminate against any employee or applicant for employment because he or she is a disabled veteran or veteran of the Vietnam era in regard to any position for which the employee or applicant for employment is qualified. The recipient agrees to take affirmative action to employ, advance in employment, and otherwise treat qualified disabled veterans and veterans of the Vietnam era without discrimination based upon their disability or veterans status in all employment practices such as the following: employment upgrading, demotion or transfer, recruitment, advertising, layoff or termination, rates of pay or other forms of compensation, and selection for training, including apprenticeship.

b. The recipient agrees that all suitable employment openings of the recipient which exist at the time of the execution of this agreement and those which occur during the performance of this agreement, including those not generated by this agreement and including those occurring at an establishment of the recipient other than the one wherein the agreement is being performed but excluding those of independently operated corporate affiliates, shall be listed at an appropriate local office of the State employment service system wherein the opening occurs. The recipient further agrees to provide such reports to such local office regarding employment openings and hires as may be required.

State and local government agencies holding Federal agreements of \$10,000 or more shall also list all their suitable openings with the appropriate office of the State employment service but are not required to provide those reports set forth in paragraphs d. and e.

c. Listing of employment openings with the employment service system pursuant to this clause shall be made at least concurrently with the use of any other recruitment source or effort and shall involve the normal obligations which attach to the placing of a bona fide job order, including the acceptance of referrals of veterans and nonveterans. The listing of employment openings does not require the hiring of any particular job applicant or from any particular group of job applicants, and nothing herein is intended to relieve the recipient from any requirements in Executive Orders or regulations regarding nondiscrimination in employment.

d. The reports required by paragraph b. of this clause shall include, but not be limited to, periodic reports which shall be filed at least quarterly with the appropriate local office or, where the recipient has more than one hiring

location in a State, with the central office of that State employment service. Such reports shall indicate for each hiring location (1) the number of individuals hired during the reporting period, (2) the number of nondisabled veterans of the Vietnam era hired, (3) the number of disabled veterans of the Vietnam era hired, and (4) the total number of disabled veterans hired. The reports should include covered veterans hired for on-the-job training under 38 U.S.C. 1787. The recipient shall submit a report within 30 days after the end of each reporting period wherein any performance is made on this agreement identifying data for each hiring location. The recipient shall maintain at each hiring location copies of the reports submitted until the expiration of 1 year after final payment under the agreement, during which time these reports and related documentation shall be made available, upon request, for examination by any authorized representatives of the Grants and Cooperative Agreements Officer or of the Secretary of Labor. Documentation would include personnel records respecting job openings, recruitment, and placement.

e. Whenever the recipient becomes contractually bound to the listing provisions of this clause, it shall advise the employment service system in each State where it has establishments of the name and location of each hiring location in the State. As long as the recipient is contractually bound to these provisions and has so advised the State system, there is no need to advise the State system of subsequent agreements. The recipient may advise the State system when it is no longer bound by this agreement clause.

f. This clause does not apply to the listing of the employment openings which occur and are filled outside the 50 states, the District of Columbia, Puerto Rico, Guam, and the Virgin Islands.

g. The provisions of paragraphs b., c., d., and e. of this clause do not apply to openings which the recipient proposes to fill from within his own organization or to fill pursuant to a customary and traditional employer-union hiring arrangement. This exclusion does not apply to a particular opening once an employer decides to consider applicants outside of his own organization or employer-union arrangement for that opening.

h. As used in this clause:

(1) "All suitable employment openings" includes, but is not limited to, openings which occur in the following job categories: production and nonproduction; plant and office; laborers and mechanics; supervisory and nonsupervisory; technical; and executive, administrative, and professional openings that are compensated on a salary basis of less than \$25,000 per year. This term includes full-time employment, temporary employment of more than 3 days' duration, and part-time employment. It does not include openings which the recipient proposes to fill from within its own organization or to fill pursuant to a customary and traditional employer-union hiring arrangement nor openings in an educational institution which are restricted to students of that institution. Under the most compelling circumstances, an employment opening may not be suitable for listing, including such situations where the needs of the Government cannot reasonably be otherwise supplied, where listing would be contrary to national security, or where the requirement of listing would otherwise not be for the best interest of the Government.

(2) "Appropriate office of the State employment service system" means the local office of the Federal/State national system of public employment offices with assigned responsibility for serving the area where the employment opening is to be filled, including the District of Columbia, Guam, Puerto Rico, and the Virgin Islands.

(3) "Openings which the recipient proposes to fill from within his own organization" means employment openings for which no consideration will be given to persons outside the recipient's organization (including any affiliates,

subsidiaries, and the parent companies) and includes any openings which the recipient proposes to fill from regularly established "recall" files.

(4) "Openings which the recipient proposes to fill pursuant to a customary and traditional employer-union hiring arrangement" means employment openings which the recipient proposes to fill from union halls, which is part of the customary and traditional hiring relationship which exists between the recipient and representatives of his employees.

i. The recipient agrees to comply with the rules, regulations, and relevant orders of the Secretary of Labor issued pursuant to the Act.

j. In the event of the recipient's noncompliance with the requirements of this clause, actions for noncompliance may be taken in accordance with the rules, regulations, and relevant orders of the Secretary of Labor issued pursuant to the Act.

k. The recipient agrees to post in conspicuous places available to employees and applicants for employment notices in a form to be prescribed by the Director, provided by or through the Grants and Cooperative Agreements Officer. Such notice shall state the recipient's obligation under the law to take affirmative action to employ and advance in employment qualified disabled veterans and veterans of the Vietnam era for employment, and the rights of applicants and employees.

l. The recipient will notify each labor union or representative of workers with which it has a collective bargaining agreement or other contract understanding that the recipient is bound by terms of the Vietnam Era Veteran's Readjustment Assistance Act and is committed to take affirmative action to employ and advance in employment qualified disabled veterans and veterans of the Vietnam era.

m. The recipient will include the provisions of this clause in every contract or purchase order of \$10,000 or more unless exempted by rules, regulations, or orders of the Secretary issued pursuant to the Act, and such provisions will be binding upon each contractor or vendor. The recipient will take such action with respect to any contract or purchase order as the Director of the Office of Federal Contract Compliance Programs may direct to enforce such provisions, including action for noncompliance.

#### 6. Employment of the Handicapped

a. The recipient will not discriminate against any employee or applicant for employment because of physical or mental handicap in regard to any position for which the employee or applicant is qualified. The recipient agrees to take affirmative action to employ, advance in employment, and otherwise treat qualified handicapped individuals without discrimination based upon their physical or mental handicap in all employment practices such as the following: employment, upgrading, demotion or transfer, recruitment, advertising, layoff or termination, rates of pay or other forms of compensation, and selection for training including apprenticeship.

b. The recipient agrees to comply with the rules, regulations, and relevant orders of the Secretary of Labor issued pursuant to the Rehabilitation Act of 1973, as amended.

c. In the event of the recipient's noncompliance with the requirements of this clause, actions for noncompliance may be taken in accordance with the rules, regulations, and relevant orders of the Secretary of Labor issued pursuant to the Act.

d. The recipient agrees to post in conspicuous places, available to employees and applicants for employment, notices in a form to be prescribed by

the Director, Office of Federal Contract Compliance Programs, Department of Labor, provided by or through the Grants and Cooperative Agreements Officer. Such notices shall state the recipient's obligation under the law to take affirmative action to employ and advance in employment qualified handicapped employees and applicants for employment, and the rights of applicants and employees.

e. The recipient will notify each labor union or representative of workers with which it has a collective bargaining agreement or other contract understanding, that the recipient is bound by the terms of section 503 of the Act and is committed to take affirmative action to employ and advance in employment physically and mentally handicapped individuals.

f. The recipient will include the provisions of this clause in every contract or purchase order of \$2,500 or more unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to section 503 of the Act, so that such provisions will be binding upon each contractor or vendor. The recipient will take such action with respect to any contract or purchase order as the Director, Office of Federal Contract Compliance Programs, may direct to enforce such provisions, including action for noncompliance.

#### 7. Clean Air and Water

Applicable only if the agreement exceeds \$100,000 or a facility to be used has been the subject of a conviction under the Clean Air and Water Act, 42 USC 1857c-8(c)(1), or the Federal Water Pollution Control Act, 33 USC 1319(c); and is listed by EPA, or the agreement is not otherwise exempt.

a. The recipient agrees as follows:

(1) To comply with all the requirements of section 114 of the Clean Air Act, as amended (42 USC 1857, et seq., as amended by Public Law 91-604) and section 308 of the Federal Water Pollution Control Act (33 USC 1251, et seq., as amended by Public Law 92-500), respectively, relating to inspection, monitoring, entry reports, and information, as well as other requirements specified in section 114 and section 308 of the Air Act and Water Act, respectively, and all regulations and guidelines issued thereunder before the award of this agreement.

(2) That no portion of the work required by this agreement will be performed in a facility listed on the Environmental Protection Agency List of Violating Facilities on the date when this agreement was awarded unless and until the EPA eliminates the name of such facility or facilities from such listing.

(3) To use its best efforts to comply with clean air standards and clean water standards at the facility in which the agreement is being performed.

(4) To insert the substance of the provisions of this clause in any nonexempt grant or cooperative agreement, including this subparagraph a.(4).

b. The terms used in this clause have the following meanings:

(1) The term "Air Act" means the Clean Air Act, as amended (42 USC 1857 et seq., as amended by Public Law 91-604).

(2) The term "Water Act" means Federal Water Pollution Control Act, as amended (33 USC 1251 et seq., as amended by Public Law 92-500).

(3) The term "clean air standards" means any enforceable rules, regulations, guidelines, standards, limitations, orders, controls, prohibitions, or other requirements which are contained in, issued under, or otherwise adopted pursuant to the Air Act or Executive Order No. 11738, an applicable implementation plan as described in section 110(d) of the Clean Air Act 42 US

1857c-5(d), an approved implementation procedure or plan under section 111(c) or section 111(d), respectively, of the Air Act 42 USC 1857c-6(c) or (d), or an approved implementation procedure under section 112(d) of the Air Act 42 USC 1857c-7(d).

(4) The term "clean water standards" means any enforceable limitation, control, condition, prohibition, standard, or other requirement which is promulgated pursuant to the Water Act or contained in a permit issued to a discharger by the Environmental Protection Agency or by a State under an approved program as authorized by section 402 of the Water Act (33 US 1342), or by a local government to ensure compliance with pretreatment regulations as required by section 307 of the Water Act (33 U.S.C. 1317).

(5) The term "compliance" means compliance with the clean air or water standards. Compliance shall also mean compliance with schedule or plan ordered or approved by a court of competent Jurisdiction, the Environmental Protection Agency, or an air or water pollution control agency in accordance with the requirements of the Air Act or Water Act and regulations issued pursuant thereto.

(6) The term "facility" means any building, plant, installation, structure, mine, vessel or other floating craft, location, or site of operations, owned, leased, or supervised by a recipient or subcontractor, to be utilized in the performance of an agreement or subcontract. Where a location or site of operations contains or includes more than one building, plant, installation, or structure, the entire location or site shall be deemed to be a facility except where the Director, Office of Federal Activities, Environmental Protection Agency, determines that independent facilities are collocated in one geographical area.

### 8. Convict Labor

In connection with the performance of work under this agreement, the recipient agrees not to employ any person undergoing sentence of imprisonment except as provided by Public Law 89-176, September 10, 1965 18 USC 4082(c)(2), Executive Order No. 11755, December 29, 1973.

### 9. Contracting with Small and Minority Firms, Women's Business Enterprises and Labor Surplus Area Firms - Department of the Interior (DEC 1994)

It is a national policy to award a fair share of contracts to small and minority business firms. The Department of the Interior is strongly committed to the objectives of this policy and encourages all recipients of its grants and cooperative agreements to take affirmative steps to ensure such fairness.

a. The grantee and subgrantee shall take all necessary affirmative steps to assure that minority firms, women's business enterprises, and labor surplus area firms are used when possible.

b. Affirmative steps shall include:

(1) Placing qualified small and minority businesses and women's business enterprises on solicitation lists;

(2) Assuring that small and minority businesses, and women's business enterprises are solicited whenever they are potential sources;

(3) Dividing total requirements, when economically feasible, into smaller tasks or quantities to permit maximum participation by small and minority business, and women's business enterprises;

(4) Establishing delivery schedules, where the requirement permits,

which encourage participation by small and minority business, and women's business enterprises;

(5) Using the services and assistance of the Small Business Administration, and the Minority Business Development Agency of the Department of Commerce as appropriate, and

(6) Requiring the prime contractor, if subcontracts are to be let, to take the affirmative steps listed in b.(1) through (5) above.

10. Stevens Amendment - Reclamation (SEP 1992)

(a) No amount of any grant made by a Federal agency shall be used to finance the acquisition of goods or services (including construction services) unless the recipient of the grant agrees, as a condition for the receipt of such grant, to -

(1) specify in any announcement of the awarding of a contract for the procurement of goods or services (including construction services) the amount of Federal funds that will be used to finance the acquisition; and

(2) express the amount announced pursuant to paragraph (1) as a percentage of the total costs of the planned acquisition.

(b) The requirements of subsection (a) shall not apply to a procurement for goods or services (including construction services) that has an aggregate value of less than \$500,000.

11. Notice Regarding Buy American Act

Pursuant to Section 501 of the Energy and Water Development Appropriations Act, 1995, Public Law 103-316, 108 Stat. 1723, please be advised of the following:

It is the sense of the Congress that, to the greatest extent practicable, all equipment and products purchased with funds made available in this Act should be American-made.

12. Use of the Metric System - Reclamation (MAR 1993)

Section 5163 of Public Law 100-418, the Omnibus Trade and Competitiveness Act of 1988 (Trade Act), amended the Metric Conversion Act of 1975 and designated the metric system of weights and measures for United States trade and commerce.

As a result of the Trade Act, the President issued Executive Order 12770 dated July 25, 1991, to implement the Congressional designation of the metric system of measurement as the preferred system of weights and measures for United States trade and commerce.

The metric system of measurement shall be used in grants and cooperative agreements, except to the extent that such use is impractical or is likely to cause significant inefficiencies, or is not economically feasible. To the extent possible, scientific and technical reports and recipient-furnished materials provided under the agreement, including computer programs, shall use appropriate metric units.

13. Resolving Disagreements - Reclamation (Mar 1993)

When entering into a cooperative agreement with a recipient, Reclamation commits itself to working with the recipient in a harmonious manner to achieve the objectives of the project successfully. When disagreements arise between the parties, they must be resolved according to the procedures discussed below:



a. Reclamation shall attempt first to resolve disagreements with the recipient through informal discussion among the Grants or Contract Specialist, the Program Officer, and the recipient's Project Director.

b. If the disagreement cannot be resolved through informal discussion between these parties, the Grants Specialist and the Program Officer shall document the nature of the disagreement and bring it to the attention of the Grants Officer.

c. After reviewing the facts of the disagreement, as presented by the Grants and Program Offices, the Grants Officer will arrange a formal meeting. If agreement still cannot be reached, the parties will collectively decide on any varied approaches which might be used to resolve the disagreement. The parties shall be responsible for their individual expenses related to any approach utilized to resolve the disagreement.

d. Ultimately, if all other attempts at resolving the disagreement fails, a decision will be made by the (Chief, Acquisition and Assistance Management Services or Regional Director, whichever is applicable), whose decision shall be final and conclusive.

Any post award issue will be open for resolution in accordance with the above procedures, with the exception of disagreements regarding continuation of the agreement (since either party may terminate the agreement with the specified notice), or other matters specifically addressed by the agreement itself.

#### 14. Forms and Certifications

The following forms and certifications are incorporated by reference and made a part of this agreement:

Enclosure A - Certifications Regarding Debarment, Suspension, and Other Responsibility Matters, Drug-free Workplace Requirements and Lobbying (DI-2010)

Enclosure B - Assurances - Non-Construction Programs (SF 424B) or Assurances - Construction Programs (SF 424D), as applicable

**Certifications Regarding Debarment, Suspension and  
Other Responsibility Matters, Drug-Free Workplace  
Requirements and Lobbying**

Persons signing this form should refer to the regulations referenced below for complete instructions:

Certification Regarding Debarment, Suspension, and Other Responsibility Matters - Primary Covered Transactions - The prospective primary participant further agrees by submitting this proposal that it will include the clause titled, "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transaction," provided by the department or agency entering into this covered transaction, without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions. See below for language to be used; use this form for certification and sign; or use Department of the Interior Form 1954 (DI-1954). (See Appendix A of Subpart D of 43 CFR Part 12.)

Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transactions - (See Appendix B of Subpart D of 43 CFR Part 12.)

Certification Regarding Drug-Free Workplace Requirements - Alternate I. (Grantees Other Than Individuals) and Alternate II. (Grantees Who are Individuals) - (See Appendix C of Subpart D of 43 CFR Part 12)

Signature on this form provides for compliance with certification requirements under 43 CFR Parts 12 and 18. The certifications shall be treated as a material representation of fact upon which reliance will be placed when the Department of the Interior determines to award the covered transaction, grant, cooperative agreement or loan.

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**PART A: Certification Regarding Debarment, Suspension, and Other Responsibility Matters - Primary Covered Transactions**

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*CHECK\_\_IF THIS CERTIFICATION IS FOR A PRIMARY COVERED TRANSACTION AND IS APPLICABLE.*

- (1) The prospective primary participant certifies to the best of its knowledge and belief, that it and its principals:
  - (a) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;
  - (b) Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;
  - (c) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (1)(b) of this certification; and
  - (d) Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default.
- (2) Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

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**PART B: Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transactions**

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*CHECK\_\_IF THIS CERTIFICATION IS FOR A LOWER TIER COVERED TRANSACTION AND IS APPLICABLE.*

- (1) The prospective lower tier participant certifies, by submission of this proposal, that neither it nor its principals is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal department or agency.
- (2) Where the prospective lower tier participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

PART E: Certification Regarding Lobbying  
Certification for Contracts, Grants, Loans, and Cooperative Agreements

CHECK ☐ IF CERTIFICATION IS FOR THE AWARD OF ANY OF THE FOLLOWING AND THE AMOUNT EXCEEDS \$100,000: A FEDERAL GRANT OR COOPERATIVE AGREEMENT; SUBCONTRACT, OR SUBGRANT UNDER THE GRANT OR COOPERATIVE AGREEMENT.

CHECK ☐ IF CERTIFICATION IS FOR THE AWARD OF A FEDERAL LOAN EXCEEDING THE AMOUNT OF \$150,000, OR A SUBGRANT OR SUBCONTRACT EXCEEDING \$100,000, UNDER THE LOAN.

The undersigned certifies, to the best of his or her knowledge and belief, that:

- (1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, and officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
- (2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.
- (3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

As the authorized certifying official, I hereby certify that the above specified certifications are true.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL



TYPED NAME AND TITLE Raymond D. Hart, Chief of the Division of Local Assistance

DATE

4/19/96

## DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C. 1352  
(See reverse for public burden disclosure.)

<p>1. Type of Federal Action:</p> <p><input checked="" type="checkbox"/> a. contract  <input type="checkbox"/> b. grant  <input type="checkbox"/> c. cooperative agreement  <input type="checkbox"/> d. loan  <input type="checkbox"/> e. loan guarantee  <input type="checkbox"/> f. loan insurance</p>	<p>2. Status of Federal Action:</p> <p><input checked="" type="checkbox"/> a. bid/offer/application  <input type="checkbox"/> b. initial award  <input type="checkbox"/> c. post-award</p>	<p>3. Report Type:</p> <p><input checked="" type="checkbox"/> a. initial filing  <input type="checkbox"/> b. material change</p> <p>For Material Change Only:  year _____ quarter _____  date of last report _____</p>
<p>4. Name and Address of Reporting Entity:</p> <p><input type="checkbox"/> Prime <input type="checkbox"/> Subawardee  Tier _____ if known</p> <p>Congressional District, if known: _____</p>		<p>5. If Reporting Entity in No. 4 is Subawardee, Enter Name and Address of Prime:</p> <p>Congressional District, if known: _____</p>
<p>6. Federal Department/Agency:</p>	<p>7. Federal Program Name/Description:</p> <p>CFDA Number, if applicable: _____</p>	
<p>8. Federal Action Number, if known: _____</p>	<p>9. Award Amount, if known: \$ _____</p>	
<p>10. a. Name and Address of Lobbying Entity (if individual, last name, first name, MI):</p> <p>None</p>		<p>b. Individuals Performing Services (including address if different from No. 10a) (last name, first name, MI):</p>
(ATTACH CONTINUATION SHEET(S) SF-LLL-A, if necessary)		
<p>11. Amount of Payment (check all that apply):</p> <p>\$ _____ <input type="checkbox"/> actual <input type="checkbox"/> planned</p>	<p>12. Type of Payment (check all that apply):</p> <p><input type="checkbox"/> a. retainer  <input type="checkbox"/> b. one-time fee  <input type="checkbox"/> c. commission  <input type="checkbox"/> d. contingent fee  <input type="checkbox"/> e. deferred  <input type="checkbox"/> f. other, specify: _____</p>	
<p>13. Form of Payment (check all that apply):</p> <p><input type="checkbox"/> a. cash  <input type="checkbox"/> b. in-kind; specify: nature _____  value _____</p>		
<p>14. Brief Description of Services Performed or to be Performed and Date(s) of Service, including officer(s), employee(s), or Member(s) contacted, for Payment indicated in Item 11:</p> <p>Conduct study and demonstration project to improve irrigation efficiency and reduce irrigation surface runoff in the Imperial Valley.</p>		
(ATTACH CONTINUATION SHEET(S) SF-LLL-A, if necessary)		
<p>15. Continuation Sheet(s) SF-LLL-A attached: <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>		
<p>16. Information furnished through this form is required by 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the law under which this transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress upon enactment and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.</p>		<p>Signature: <u>Raymond D. Hart</u></p> <p>Print Name: <u>Raymond D. Hart</u></p> <p>Title: <u>Chief, Division of Local Assistance</u></p> <p>Telephone No.: <u>(916) 327-1646</u> Date: _____</p>
U.S. Federal Government		Authorized for Local Reproduction Standard Form - 288

## ASSURANCES — NON-CONSTRUCTION PROGRAMS

Note: Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant I certify that the applicant:

1. Has the legal authority to apply for Federal assistance, and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project costs) to ensure proper planning, management and completion of the project described in this application.
2. Will give the awarding agency, the Comptroller General of the United States, and if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to the award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.
3. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.
4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.
5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§ 4723-4763) relating to prescribed standards for merit systems for programs funded under one of the nineteen statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).
6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C. §§ 1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. § 794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U.S.C. §§ 5101-5107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§ 523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. 290 dd-3 and 290 ee-3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. § 3601 et seq.), as amended, relating to non-discrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made; and (j) the requirements of any other nondiscrimination statute(s) which may apply to the application.
7. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.
8. Will comply with the provisions of the Hatch Act (5 U.S.C. §§ 1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.
9. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§ 276a to 276a-7), the Copeland Act (40 U.S.C. § 276c and 18 U.S.C. §§ 874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§ 327-333), regarding labor standards for federally assisted construction subagreements.

## STANDARD CLAUSES - CONTRACTS WITH THE UNITED STATES BUREAU OF RECLAMATION

**Workers' Compensation Clause.** Contractor affirms that it is aware of the provisions of Section 3700 of the California Labor Code which require every employer to be insured against liability for workers' compensation or to undertake self-insurance in accordance with the provisions of that Code, and Contractor affirms that it will comply with such provisions before commencing the performance of the work under this contract. This provision shall apply to the extent provided by federal laws, rules and regulations.

**Claims Dispute Clause.** Any claim that Contractor may have regarding the performance of this agreement including, but not limited to, claims for additional compensation or extension of time, shall be submitted to the Director, Department of Water Resources, within thirty days of its accrual. State and Contractor shall then attempt to negotiate a resolution of such claim and process an amendment to this agreement to implement the terms of any such resolution. However, Contractor does not waive any rights or duties it may have as may be provided by federal laws, rules and regulations.

**Nondiscrimination Clause.** During the performance of this contract, the recipient, contractor and its subcontractors shall not deny the contract's benefits to any person on the basis of religion, color, ethnic group identification, sex, age, physical or mental disability, nor shall they discriminate unlawfully against any employee or applicant for employment because of race, religion, color, national origin, ancestry, physical handicap, mental disability, medical condition, marital status, age (over 40), or sex. Contractor shall insure that the evaluation and treatment of employees and applicants for employment are free of such discrimination. Contractor shall comply with the provisions of the Fair Employment and Housing Act (Government Code Section 12900 et seq.), the regulations promulgated thereunder (California Administrative Code, Title 2, Sections 7285.0 et seq.), the provisions of Article 9.5, Chapter 1, Part 1, Division 5, Title 2 of the Government Code (Government Code Sections 11135 - 11139.5), and the regulations or standards adopted by the awarding State agency to implement such article. Contractor or recipient shall permit access by representatives of the Department of Fair Employment and Housing and the awarding State agency upon reasonable notice at any time during the normal business hours, but in no case less than 24 hours' notice, to such of its books, records, accounts, other sources of information and its facilities as said Department or Agency shall require to ascertain compliance with this clause. Recipient, Contractor and its subcontractors shall give written notice of their obligations under this clause to labor organizations with which they have a collective bargaining or other agreement. The Contractor shall include the nondiscrimination and compliance provisions of this clause in all subcontracts to perform work under the contract.

**Availability of Funds.** Work to be performed under this contract is subject to availability of funds through the State's normal budget process.

**Audit Clause.** For contracts in excess of \$10,000, unless otherwise provided by federal laws, rules or regulations, the contracting parties shall be subject to the examination and audit of the State Auditor for a period of three years after final payment under the contract. (Government Code Section 8545.7).

**Payment Retention Clause.** Ten percent of any progress payments that may be provided for under this contract shall be withheld per Public Contract Code Sections 10346 and 10379 pending satisfactory completion of all services under the contract.

**Reimbursement Clause.** If applicable, travel and per diem expenses to be reimbursed under this contract shall be at the same rates the State provides for unrepresented employees in accordance with the provisions of Title 2, Chapter 3, of the California Code of Regulations. Contractor's designated headquarters for the purpose of computing such expenses shall be: Sacramento, CA

**Americans With Disabilities Act.** By signing this contract, Contractor assures the State that it complies with the Americans With Disabilities Act (ADA) of 1990, (42 U.S.C. 12101 et seq.), which prohibits discrimination on the basis of disability, as well as all applicable regulations and guidelines issued pursuant to the ADA.

**Conflict of Interest.** Current State Employees: a) No State officer or employee shall engage in any employment, activity or enterprise from which the officer or employee receives compensation or has a financial interest and which is sponsored or funded by any State agency, unless the employment, activity or enterprise is required as a condition of regular State employment. b) No State officer or employee shall contract on his or her own behalf as an independent contractor with any State agency to provide goods or services.

Former State Employees: a) For the two-year period from the date he or she left State employment, no former State officer or employee may enter into a contract in which he or she engaged in any of the negotiations, transactions, planning, arrangements or any part of the decision-making process relevant to the contract while employed in any capacity by any State agency. b) For the twelve-month period from the date he or she left State employment, no former State officer or employee may enter into a contract with any State agency if he or she was employed by that State agency in a policy-making position in the same general subject area as the proposed contract within the twelve-month period prior to his or her leaving State service.

4-48

State of California

The Resources Agency

DEPARTMENT OF WATER RESOURCES

FAX COVER SHEET *Email*

DEPARTMENT OF WATER RESOURCES  
Division of Local Assistance  
1020 Ninth Street  
P.O. Box 942836  
Sacramento, CA 94236-0001 USA

*Contracts: Claire Dale*  
*Mark Grisham*  
*916-752-3243*  
*9 Nancy Brucey*

*2/16/96*  
Date

*9*  
Number of Pages, Including FAX  
Cover Sheet

FAX TRANSMITTED TO:

*Mr. Tim O'Halloran*  
Name

*iid*  
Organization

*Imperial*  
Location

*Imperial*  
City

*619/339-9262*  
FAX Telephone Number

*619/339-9263*  
Office Telephone Number

FAX FROM:



Fawzi Karajeh, Ph D.  
Program Manager  
Agricultural Drainage Reduction

Department of Water Resources  
Division of Local Assistance  
Office of Water Conservation  
1020 Ninth Street  
Sacramento, CA 95814  
fkara@water.ca.gov

(916) 327-1828  
FAX (916) 327-1815  
CALNET 457-1828  
Pager/Mobile (916) 552-2813

COMMENTS: *at last!*  
*For your review, please find attached the draft contract*  
*between DWR and USBR and the draft contract*  
*between DWR, USBR, and iid.*  
*Thank you for your support and interest.*

Sender (check if applicable)

*F-K*Discard Copy ☐ Yes ☐ NoOriginal letter to follow ☐ Yes ☐ No

If you do not receive all pages or have any problems with receiving this  
FAX, please call (916) 327-1775.



## INTERAGENCY AGREEMENT

STD. 12 (REV. 9-89)

NUMBER

B-80560

THIS AGREEMENT is entered into this 15th day of June, 1995,  
by and between the undersigned State Agencies:

Set forth services, materials, or equipment to be furnished, or work to be performed, and by whom,  
time for performance including the terms, date of commencement and date of completion, and provision  
for payment per (1225 and 8752-8752.1 SAM.)

## Distribution:

- ☐ Agency providing services  
☐ Agency receiving services  
☐ Department of General Services  
(unless exempt from DGS approval)  
☐ Controller

General Provision:Section One: Purpose of Contract:

This study will focus on the development and demonstration of a new method to predict irrigation cutoff time from pre-determined soil moisture status of the clay soil of interest. Issues related to salinity, irrigation management, and water quality will also be addressed in the project including crop coefficients for alfalfa and sudan grass. Since soil salinity and water management are effected by water table depth, a major part of this study will be to quantify the effects of water table control on soil salinity, water infiltration rates, and irrigation efficiency. The study will be conducted over three years in order to observe cumulative aspects of reduced water table depth on soil salinity and consumptive water use.

(Continued on 4 sheets which are hereby attached and made a part hereof)

NAME OF STATE AGENCY RECEIVING SERVICES Department of Water Resources	NAME OF STATE AGENCY PROVIDING SERVICES The Regents of the University of CA
CALLER ABOVE (SHORT NAME) DWR	CALLER ABOVE (SHORT NAME) U.C. Regents
AUTHORIZED SIGNATURE >	AUTHORIZED SIGNATURE ▷
PRINTED NAME AND TITLE OF PERSON SIGNING Raymond D. Hart, Chief Division of Local Assistance	PRINTED NAME AND TITLE OF PERSON SIGNING Carol Berman Contract and Grant Coordinator
FUND NUMBER AND NAME	FUND NUMBER AND NAME

MOUNT ENCUMBERED BY THIS DOCUMENT \$	PROGRAM/CATEGORY (CODE AND TITLE)		FUND TITLE	
	(OPTIONAL USE)			
	ITEM	CHAPTER	STATUTE	FISCAL YEAR
PRIOR AMOUNT ENCUMBERED FOR THIS CONTRACT \$	OBJECT OF EXPENDITURE (CODE AND TITLE)			
TOTAL AMOUNT ENCUMBERED TO DATE \$				
I hereby certify upon my own personal knowledge that budgeted funds are available for the period and purpose of the expenditure stated above.		T.B.A. NO.		B.R. NO.
SIGNATURE OF ACCOUNTING OFFICER		DATE		

Department of General Services  
Use Only

The Regents of the University of California  
Contract No. B-80560  
Page 2

### Section Two: Objectives:

Conduct a research and demonstration project that will:

1. improve irrigation efficiency,
2. reduce surface runoff,
3. determine the contribution of shallow saline water tables to crop evapotranspiration in heavy clay soils,
4. determine the effect of water table control on irrigation management and consumptive use of water by alfalfa and sudangrass (including crop coefficients for alfalfa and sudangrass),
5. develop a relatively simple approach to predict irrigation cutoff time from pre-determined soil moisture measurements,
6. increase the utilization of CIMIS for irrigation scheduling,
7. develop a user-friendly computer program and irrigation management spreadsheets for efficient irrigation management practices,
8. publish a handbook about the best management practices for reducing surface and subsurface drainage water, and
9. conduct field days, demonstrations, seminars, and publish results in both popular and scientific media.

### Section Three: Workplan

- sudangrass planted for three successive years on the same ground (Field No. 1)
- sudangrass planted in March and harvested in October
- alfalfa planted in October 1995 (duration of crop: 3 years, Field No. 2)
- water table lowered from 5 to 15 ft in upper 500 ft of field No. 1 (sudangrass)
- tile drains blocked in upper 500 ft of field No. 2 (alfalfa)
- hay yield at each cutting (weighing bales in field)

The Regents of the University of California  
Contract No. B-80560  
Page 3

DRAFT

- infiltration rates and irrigation performance characteristics will be evaluated for each treatment throughout the experiment
- soil samples for chemical analysis will be collected throughout the experiment
- drainage flow rate will be monitored
- surface runoff will be evaluated and water samples will be collected on a regular basis
- water table elevation and salinity will be monitored on a regular basis (32 observation wells in each field)
- consumptive water use is determined between irrigations
- ANOVA and time series analysis methods will be used to determine statistical parameters of concern in the experiments

#### Section Four: Responsibilities

The project managers will be Khaled M. Bali of the University of California Cooperative Extension, and Fawzi Karajeh of the Department of Water Resources, Water Conservation Office.

#### Section Five: Terms and Costs of Contract

The term of this contract is from June 15, 1995 through December 31, 1998, but, the agreement shall not be effective until the final approval by the Department of General Services. The cost of the project, subject to availability of funds from all funding participants, shall not exceed \$137,597.

If any party reduces its funding level, DWR will reduce the total cost of the project by the same amount.

A Project Advisory Committee consisting of representative(s) of DWR as the project manager, UCRs as the contractor, USBR and IID as cooperative agencies, will be formed to oversee the project development.

#### Section Six: Contract Payments

1. The state agrees to pay the contractor an amount equal to the latter's cost of performance not to exceed \$137,597 in accordance with 8752 of the State Administrative Manual. Schedule of payments will be as follows:

The Regents of the University of California  
Contract No. B-80560  
Page 4

First Progress Report	February 28, 1996	25,000.
Second Progress Report (annual)	December 31, 1996	25,000.
Third Progress Report	May 31, 1997	25,000.
Fourth Progress Report (annual)	December 31, 1997	25,000.
Fifth Report	May 31, 1998	25,000.
Final Progress Report	December 31, 1998	12,597.

2. Ten percent of any progress payments that may be provided for under this contract shall be withheld pending satisfactory completion of all services under the contract.

3. Payments shall be made in arrears after receipt of satisfactory reports and invoices and shall include DWR's contract number and should be submitted on contractor's letterhead stationary in triplicate to:

Department of Water Resources  
Water Conservation Office  
1020-Ninth Street, Third Floor  
Attention: Fawzi Karajeh  
Sacramento, CA 95814

#### Section Seven: Reports and Presentations

1. The contractor shall submit five progress reports and a final report as described in section six. For each report, three hard copies, a master copy, and a copy on disk shall be sent to:

Department of Water Resources  
Water Conservation Office  
1020-Ninth Street, Third Floor  
Attention: Fawzi Karajeh  
Sacramento, CA 95814

2. The contractor will be asked as the project progresses to give verbal progress reports to the project advisory committee and/or the agricultural water management subcommittee at least two times a year and not to exceed four times a year.

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The Regents of the University of California  
Contract No. B-80560  
Page 5

3. Either party shall be free to use, release, make a presentation, or publish all or part of the data and results of the study or the reports. In doing so, each party must give credit for the contribution of the other.

#### Section Eight: Agreements

1. It is further agreed that the state, by fact of this agreement, makes no commitments nor incurs any liability, monetarily or otherwise, to any cooperators or subcontractors solicited or hired by the contractor for Interagency Agreement No. B-80560. It shall be the contractor's sole responsibility to complete all tasks and deliver the reports as required by this contract at the cost herein stated.

2. The cooperators agree to proceed with this contract due to time constrain to initiate field work and to take advantage of the coming irrigation season. It is provide that the scope of this work be expanded to additional task(s) to cover on-farm field data collection and analyses. In such event, upon mutual agreement of all cooperators, the contractor agree to undertake such work. Additional study task(s) may be done through an amendment to this contract or through new one. The additional cost of such new task(s) will be negotiated at that time with the contractor.

#### Section Nine: Exhibits

Exhibit A, The standard clauses, are attached and hereby made a part of this agreement.

Exhibit B, The Contractor's Proposal, is attached and hereby made a part of this agreement.

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State of California

DEPARTMENT OF WATER RESOURCES

The Resources Agency

Agreement No. B-80560Exhibit A**STANDARD CLAUSES -  
INTERAGENCY AGREEMENTS**

**Audit Clause.** For contracts in excess of \$10,000, the contracting parties shall be subject to the examination and audit of the State Auditor for a period of three years after final payment under the contract. (Government Code Section 8546.7).

**Availability of Funds.** Work to be performed under this contract is subject to availability of funds through the State's normal budget process.

**Interagency Payment Clause.** For services provided under this agreement, charges will be computed in accordance with State Administrative Manual Section 8752 and 8752.1.

**Termination Clause.** Either <sup>Party</sup>~~State agency~~ may terminate this contract upon 30 days advance written notice. The <sup>Party</sup>~~State agency~~ providing the services shall be reimbursed for all reasonable expenses incurred up to the date of termination.

**DRAFT**

(2)

**Receivable Agreement No. 165574  
Between  
The California Department of Water Resources  
and  
The United States Bureau of Reclamation, Lower Colorado River  
and  
The Imperial Irrigation District  
For  
Cooperation to Fund  
Irrigation and Drainage Management and Surface Runoff Reduction in the  
Imperial Valley Project  
To Be Conducted  
By  
The Regents of the University of California**

**DRAFT**

THIS AGREEMENT, entered into this 15th day of June 1995 by and between CALIFORNIA DEPARTMENT OF WATER RESOURCES (hereinafter called the "State"), The United States Bureau of Reclamation, Lower Colorado River (hereinafter called the "USBR"), and The Imperial Irrigation District (hereinafter called the "IID"), WITNESSETH THAT:

WHEREAS, Irrigation and Drainage Management and Surface Runoff Reduction in Imperial Valley (hereinafter called the "project") was called for by the State and prepared by the UC Regents and later reviewed and discussed by the above parties and revised by the UC Regents.

PURPOSE OF THE PROJECT, this project will focus on the development and demonstration of a new method to predict irrigation cutoff time from pre-determined soil moisture status of the clay soil of interest. Issues related to salinity, irrigation management, and water quality will also be addressed in the project. Since soil salinity and water management are affected by water table depth, a major part of this study will be to quantify the effect of water table control on soil salinity. The study will be conducted over three years in order to observe cumulative consumptive water use. The purpose of this project will be achieved according to the Contract B-80560 Section Two.

TERMS AND COSTS OF THE CONTRACT, the term of this contract is from June 15, 1995 through December 31, 1998. The cost of the project, upon the availability of funds from all funding participants, shall not exceed \$137,597 and is to be paid:

\$61,300 the State share from fiscal year 1994/1995 budget

\$61,300 the USBR share from money received by DWR from USBR

\$14,997 the IID share from money received by DWR from IID

If any party reduces its funding level, DWR will reduce total cost of the project by that amount.

RESPONSIBILITIES, the State will manage the project under Contract B-80560.

Receivable Agreement No. 165574

Page 2

The contractor will submit to DWR an original of five progress reports and a final report with copies to both USBR and DWR according to the schedule stated in the Contract B-80560 Section Seven.

AGREEMENT, the cooperators agree to proceed with this contract due to time constraint, to initiate field work, and to take advantage of the coming irrigation season. It is provided that the scope of this work be expanded to additional task(s) to cover on farm field data collection and analyses. In such event, upon mutual agreement of all parties, the Regents of the University of California agreed to undertake such work per Contract No. B-80560. Additional study task(s) may be done through an amendment to this contract or through a new one. The additional cost of such new task(s) will be negotiated at that time with the University of California Regents.

It is also agreed that either party shall be free to use, release, make a presentation, or publish all or part of the data and results of the study or the reports. In doing so, each party must give credit for the contribution of the other.

The parties hereto have executed this Agreement as of the day and year first written.

THE CALIFORNIA DEPARTMENT OF WATER RESOURCES

By \_\_\_\_\_  
Raymond D. Hart, Chief  
Division of Local Assistance

Date \_\_\_\_\_

THE UNITED STATES BUREAU OF RECLAMATION, LOWER COLORADO RIVER

By \_\_\_\_\_  
Gary Bryant  
Area Manager

Date \_\_\_\_\_

THE IMPERIAL IRRIGATION DISTRICT

By \_\_\_\_\_  
Jesse P. Silva  
Water Manager

Date \_\_\_\_\_



449



COOPERATIVE EXTENSION  
UNIVERSITY OF CALIFORNIA  
IMPERIAL COUNTY

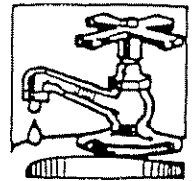
1050 E. HOLTON ROAD, HOLTVILLE, CA 92250-9615

Telephone (619) 352-9474

FAX Number (619) 352-0846

E-mail: [kmbali@ucdavis.edu](mailto:kmbali@ucdavis.edu)

cc Bob  
Elston  
David  
Stouck  
Carlos  
EN



Khaled M. Bali  
Farm Advisor  
Irrigation/Water Management

NOV 26 1991

In accordance with applicable Federal laws and University policy, the University of California does not discriminate in any of its policies, procedures, or practices on the basis of race, religion, color, national origin, sex, marital status, sexual orientation, age, veteran status, medical condition, or handicap. Inquiries regarding this policy may be addressed to Affirmative Action Director, University of California, Agriculture and Natural Resources, 300 Lakeside Drive, 6th Floor, Oakland, CA 94612-3560 (415) 987-0097.

# UNIVERSITY OF CALIFORNIA

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SANTA BARBARA • SANTA CRUZ

OFFICE OF THE VICE PRESIDENT—  
AGRICULTURE AND NATURAL RESOURCES

OFFICE OF THE PRESIDENT  
Division of Agriculture and Natural Resources  
300 Lakeside Drive, 6th Floor  
Oakland, California 94612-3560

November 7, 1997

Dr. Fawzi Karajeh  
Program Manager, Agricultural Drainage Reduction  
Office of Water Conservation  
California Department of Water Resources  
1020 Ninth Street, 3<sup>rd</sup> Floor  
Sacramento, CA 95814

On behalf of The Regents of the University of California and Vice President W.R. Gomes, enclosed is a copy of the proposal entitled "Irrigation and Drainage Management and Surface Runoff Reduction in the Imperial Valley; On-Farm Irrigation Management and Surface Runoff Reduction". The Project Leader is Khaled Bali, Cooperative Extension Farm Advisor located in Imperial County.

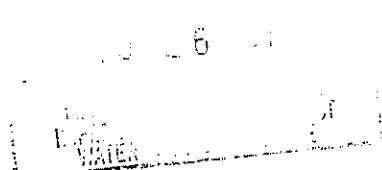
Any questions concerning the project work should be directed to Mr. Bali at (619) 352-9474. Questions regarding administrative matters such as contracts or other award documents should be directed to my attention at: University of California, Division of Agriculture and Natural Resources, 300 Lakeside Drive, 6<sup>th</sup> Floor, Oakland, CA 94612-3560.

Sincerely,

A handwritten signature in cursive script, appearing to read "Carol Berman".

Carol Berman  
Contracts and Grants Coordinator  
(510) 987-0050  
/ht

c: K. Bali/Imperial County  
R. Gonzalez/Imperial County  
A. Smith  
without enclosure





COOPERATIVE EXTENSION  
UNIVERSITY OF CALIFORNIA  
IMPERIAL COUNTY



1050 E. HOLTON ROAD  
HOLTVILLE, CA 92250-9615

TELEPHONE  
(619) 352-9474

FAX NUMBER  
(619) 352-0846

October 28, 1997

Dr. Fawzi Karajeh  
Program Manager, Agricultural Drainage Reduction  
Office of Water Conservation  
California Department of Water Resources  
1020 Ninth Street, 3rd Floor  
Sacramento, CA 95814

Dear Dr. Karajeh:

Enclosed please find a copy of our research proposal, "Irrigation and Drainage Management and Surface Runoff Reduction in the Imperial Valley; On-Farm Irrigation Management and surface Runoff Reduction" which we are submitting for review by your office. The attached project is our proposed extension of our current research and demonstration project in irrigation management in the Imperial Valley.

The objective of the attached amendment is to expand the current project to include commercial fields. The main focus of this study is to develop and demonstrate the use of a volume balance method to predict irrigation cutoff time to reduce surface runoff in the Imperial Valley. The proposed amendment is a result of our discussion with our current Project Advisory Committee, IID, USBR, and your office. I have sent a draft of the attached amendment to IID and USBR and have revised the scope of work to reflect their recommendations.

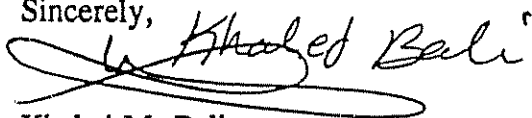
The focus of this proposed expansion is to evaluate the potential benefits and risks associated with the adaption of our runoff reduction method. The project is also designed to evaluate the performance surface irrigation systems under the current irrigation practices in the Imperial Valley. The specific objectives of this project are outlined on page three of the attached proposal.

Currently, we are monitoring ten commercial alfalfa fields (five locations) for potential inclusion in the study. These fields were selected by the IID. The budget of the attached amendment covers the costs of studying eight alfalfa and sudangrass fields ranging in size from 30-80 acres per field. We feel that the information generated from monitoring eight fields will be adequate to achieve the objectives of the project. However, we will consider the possibility of reducing or increasing the number of fields that will be included in this study. In order for us to proceed with the attached work plan, we would like to get a response from your office and the cosponsor of the project (IID and USBR) by December 31, 1997.

10/28/97 page 2/2  
Dr. Karajeh

Please let me know if you have any further questions or comments (Tel: 760-352-9474, Fax: 760-352-0846, E-mail: kmbali@ucdavis.edu). Thank you for your time and consideration.

Sincerely,

A handwritten signature in black ink, appearing to read "Khaled M. Bali", with a large, sweeping underline.

Khaled M. Bali  
Farm Advisor  
Irrigation/Water Management

c: Eldon Moore, IID  
Imperial Irrigation District  
P. O. Box 937  
Imperial, CA 92251  
Steve Jones, USBR  
USBR, Water Conservation & Advisory Center  
Lower Colorado Regional Office  
P O BOX 61470  
Boulder City, NV 89006-1470

**Project Title:** On-Farm Irrigation Management and Surface Runoff Reduction

**Location:** Imperial Valley

**Duration:** November 16, 1997 to December 31, 2000

**Budget:** The current project (July 1995-December 1998) is funded by California Department of water Resources (DWR), United States Bureau of Reclamation (USBR), and Imperial Irrigation District (IID). The cost of this Amendment will be covered by IID for the alfalfa fields (subject to IID's approval) and by USBR for the sudangrass fields (subject to USBR's approval)

*Amendment to:*

Irrigation and Drainage Management and Surface Runoff Reduction  
in the Imperial Valley

**Principal Investigators:** Khaled M. Bali, Ph.D.  
Farm Advisor, Irrigation/Water Management  
University of California Cooperative Extension  
UC Desert Research and Extension Center  
1050 E. Holton Rd., Holtville, CA 95616-9615  
(760) 352-9474 Fax: (760) 352-0846 E-mail: kmbali@ucdavis.edu

Mark E. Grismer, Ph.D.  
Professor, Hydrologic Science, Veihmeyer Hall  
Land, Air and Water Resources  
University of California, Davis, CA 95616  
(916) 752-3243 Fax: (916) 752-5262 E-mail: megrismer@ucdavis.edu

**Cooperators:** Richard L. Snyder, Ph.D.  
Bioclimatologist, Atmospheric Science, Hoagland Hall  
University of California, Davis, CA 95616  
(916) 752-4628 Fax: (916) 752-1552

Juan N. Guerrero, Ph.D.  
Farm Advisor  
UC Desert Research and Extension Center  
1050 E. Holton Rd., Holtville, CA 95616-9615  
(760) 352-9474 Fax: (760) 352-0846

## 1 Introduction:

Colorado River water is the only source of irrigation and drinking water in the Imperial Valley. About 2.8-3.0 million acre-feet of water are used every year to irrigate more than 500,000 acres of lands in the Imperial Valley. Approximately 17% of the delivered irrigation water in the Imperial Valley becomes tailwater runoff. All surface and subsurface drainage water enters the Salton Sea which has been serving as a drainage sink for the Imperial and Coachella Valleys since its formation in 1905. The Salton Sea continues to exist because of the drainage water from agriculture in Imperial and Coachella Valleys as well as flow of agricultural drainage and untreated and partially treated sewage from the Mexicali Valley. Because of drainage and its impact on the Sea, several water quality issues exist in the Imperial Valley for which water conservation plays a role.

The objective of the current project is to conduct a research and demonstration program that will improve irrigation efficiency, reduce surface runoff, utilize the shallow saline water table for new and improved irrigation and drainage management practices, determine crop coefficients for two common field crops (alfalfa and sudangrass) and increase utilization of CIMIS for irrigation scheduling. The focus of the current project is on the development and demonstration of a new method to predict irrigation cutoff time from pre-determined soil moisture status of the clay soil of interest. Issues related to salinity, irrigation management, and water quality will also be addressed in this project. Since soil salinity and water management are affected by water table depth, a major part of this study will be to quantify the effect of water table control on soil salinity, water infiltration rates, and irrigation efficiency. To observe cumulative effects of water table on soil salinity and consumptive water use, this study is conducted for three years (1995-1998). Early results from this research and demonstration project show a reduction in alfalfa yield in the second year as a result of a combination of surface runoff reduction and one-irrigation per cutting irrigation treatment. However, a significant amount of water was saved as a result of reduced surface runoff and one-irrigation per cutting treatment. Sudangrass yield was not affected as a result of the surface runoff reduction treatment which resulted in significant water savings.

The objective of this Amendment is to expand the current project to include commercial fields. The main focus of this study is to develop and demonstrate the use of a volume balance method to predict irrigation cutoff time to reduce surface runoff to approximately 5% or less of the applied water. Issues related to salinity, hay yield and quality, and water quality will be addressed in this project. Our work will focus on field crops, specifically alfalfa and sudangrass. Field crops account for almost 80% of the 500,000 acres of irrigated land in the Imperial Valley and alfalfa and sudangrass rank first and third, respectively, in terms of harvested acreage of field crops (1996 Imperial County Agricultural Crop and Livestock report). These two major field crops were grown on more than 244,000 acres of irrigated lands in the Imperial Valley in 1996.

## 2 Objectives:

The specific objectives of this Amendment are:

- 1- Determine the best management practices (BMP's) for surface runoff reduction in heavy clay and silty clay soils of the Imperial Valley.
- 2- Determine the crop coefficients for alfalfa and sudangrass under current irrigation practices in the Imperial Valley.
- 3- Determine the crop coefficients for alfalfa and sudangrass under deficit and reduced runoff irrigation practices in the Imperial Valley.
- 4- Determine the contribution of shallow saline water tables to crop evapotranspiration in heavy clay and silty clay soils of the Imperial Valley.
- 5- Determine the effect of deficit and reduced irrigation practices on hay yield and quality.
- 6- Evaluate the effect of deficit and reduced irrigation practices on soil salinity and water quality.
- 7- Develop a relatively simple approach to predict irrigation cutoff time from pre-determined soil moisture measurements for light and heavy soils of the Imperial Valley.

## 3 Procedures

### 3.1 Irrigation treatments

A total of four to six locations will be selected to conduct this experiment. **The budget of this amendment is for two alfalfa locations and two sudangrass locations.** Each location will contain two fields (30-80 acres). Each location will contain two irrigation treatments: standard irrigation (Field A) and a level of reduced irrigation treatment (Field B). Irrigation scheduling will be determined by the grower for the standard irrigation treatment (Field A) and by the project for the reduced irrigation treatment (Field B). The project will determine and order the water needed, through the grower, for the reduced irrigation treatment.

### 3.2 Alfalfa

#### 3.2.1 Possible alfalfa locations

##### - Alamitos 27

Area: Field A: 35 acres, Field B: 35 acres  
Soil type: 110, 115, and 122  
Grower: Labrucherie

##### - Elder 12 & 14

Area: Field A: 75 acres, Field B: 72 acres  
Soil type: 110 and 115  
Grower: Leimgruber

##### - Holt 86

Area: Field A: 69 acres, Field B: 69 acres



Soil type: 110 and 115  
Grower: Strahm

- North Date 72  
Area: Field A: 35 acres, Field B: 35 acres  
Soil type: 114, 115, and 122  
Grower: Newside

- North Date 59  
Area: Field A: 70 acres, Field B: 70 acres  
Soil type: 110 & 115  
Grower: Black Dog

Soil types: Holtville silty clay, wet (SCS soil type 110), Imperial silty clay, wet (SCS soil type 114), Imperial-Glenbar silty clay loams, wet (SCS soil type 115), and Meloland very fine sandy loam, wet (SCS soil type 122)

Alfalfa growing season (October 1997 - October 2000)

Planting rates and dates: Alfalfa will be planted in October or November 1997.

Pest control and harvesting: According to the commercial practices of alfalfa production in Imperial Valley.

#### **Location 1 Alfalfa (fields A & B)**

**Field A:** Standard irrigation practices in the Imperial Valley. All irrigation and cultural practices will be determined by the cooperating grower. The cooperating grower is expected to inform the project contact person of irrigation dates and hay cutting/baling dates at least 24 hours prior to each event.

#### **Measurements:**

Project staff and IID will measure the amount of applied water, surface runoff, and hay yield. Project staff will take the necessary measurements to evaluate irrigation efficiency, water use efficiency, hay yield and quality (crude protein, acid detergent fiber, and neutral detergent fiber). The following parameters will be determined:

- Average depth of applied water
- Soil moisture content prior to and after each irrigation event
- Water table depth prior to and after each irrigation event
- Water table salinity and chloride concentration prior to and after each irrigation event
- Surface runoff water during and after irrigation events
- Soil salinity (twice a year)
- Soil chloride content (twice a year)
- Average yield after each cutting
- Hay quality (twice a year)

- Drainage water salinity and chloride content
- Estimate of drainage outflow

**Field B:** Reduced irrigation treatment I. Standard irrigation practices in the Imperial Valley except that runoff will be reduced from the current average of 17% of applied water to less than 5% of applied water after stand establishment. All irrigation and cultural practices will be determined by the cooperating grower **except that the project will determine and order the amount of water needed** for irrigation. The cooperating grower is expected to inform the project contact person of irrigation dates and hay cutting/baling dates at least 24 hours prior to each event.

**Measurements:**

Project staff and IID will measure the amount of applied water, surface runoff, and hay yield. Project staff will take the necessary measurements to evaluate irrigation efficiency, water use efficiency, hay yield and quality (crude protein, acid detergent fiber, and neutral detergent fiber). The following parameters will be determined:

- Average depth of applied water
- Soil moisture content prior to and after each irrigation event
- Water table depth prior to and after each irrigation event
- Water table salinity and chloride concentration prior to and after each irrigation event
- Surface runoff water during and after irrigation events
- Soil salinity (twice a year)
- Soil chloride content (twice a year)
- Average yield after each cutting
- Hay quality (twice a year)
- Drainage water salinity and chloride content
- Estimate of drainage outflow

To account for soil spatial variability one set of borders in this treatment will be irrigated similarly to treatment A.

**Location 2 alfalfa (fields A & B)**

**Field A:** Same as field A in Location 1 alfalfa

**Measurements:**

Same as field A in Location 1 alfalfa

**Field B:** Reduced irrigation treatment II. Standard irrigation practices in the Imperial Valley except that runoff will be reduced from the current average of 17% of applied water to less than 5% of applied water after stand establishment and one irrigation per cutting between July and September. All irrigation and cultural practices will be determined by the cooperating grower **except that the project will determine and order the amount of water needed**. The cooperating grower is expected to inform the project contact person of irrigation dates and hay cutting/baling dates at least 24 hours prior to each event.

**Measurements:**

Same as field B in Location 1 alfalfa

**Location 3 alfalfa (fields A & B)**

**This is an additional possible location (not covered by the attached budget)**

**Field A:** Same as field A in Location 1 alfalfa

**Measurements:**

Same as field A in Location 1 alfalfa

**Field B:** Reduced irrigation treatment III. Standard irrigation practices in the Imperial Valley except that runoff will be reduced from the current average of 17% of applied water to less than 5% of applied water after stand establishment and one irrigation per cutting after the first cut and December 1998. After December 1998, we will resume the standard runoff reduction on this treatment. All irrigation and cultural practices will be determined by the cooperating grower except that the project will determine and order the amount of water needed. The cooperating grower is expected to inform the project contact person of irrigation dates and hay cutting/baling dates at least 24 hours prior to each event.

**Measurements:**

Same as field B in Location 1

**3.3 Sudangrass:**

**3.3.1 Possible sudangrass locations**

Sudangrass locations will be selected in March 1998

Sudangrass growing season (April - November)

Planting rates and dates: Sudangrass will be planted in April 1998.

Pest control and harvesting: According to the commercial practices of sudangrass production in Imperial Valley.

The experiment will be conducted on the same ground for three years (April 1998- December 2000). The cooperating grower will grow sudangrass in 1998 and sudangrass or any other crop after the first year for the duration of the study (according the commercial cultural practices in the Imperial Valley).

**Location 1 sudangrass (fields A & B)**

**Field A:** Standard irrigation practices in the Imperial Valley. All irrigation and cultural practices will be determined by the cooperating grower. The cooperating grower is expected to

inform the project contact person of irrigation dates and hay cutting/baling dates at least 24 hours prior to each event.

**Measurements:**

Project staff and IID will measure the amount of applied water, surface runoff, and hay (or crop) yield. Project staff will take the necessary measurements to evaluate irrigation efficiency, water use efficiency, hay yield and quality (crude protein, acid detergent fiber, and neutral detergent fiber). The following parameters will be determined:

- Average depth of applied water
- Soil moisture content prior to and after each irrigation event
- Water table depth prior to and after each irrigation event
- Water table salinity and chloride concentration prior to and after each irrigation event
- Surface runoff water during and after irrigation events
- Soil salinity (twice a year)
- Soil chloride content (twice a year)
- Average yield after each cutting (or crop harvest)
- Hay quality (twice a year)
- Drainage water salinity and chloride content
- Estimate of drainage outflow

**Field B:** Reduced irrigation treatment I. Standard irrigation practices in the Imperial Valley except that runoff will be reduced from the current average of 17% of applied water to less than 5% of applied water after stand establishment. All irrigation and cultural practices will be determined by the cooperating grower except that the project will determine and order the amount of water needed for irrigation. The cooperating grower is expected to inform the project contact person of irrigation dates and hay cutting/baling dates at least 24 hours prior to each event.

**Measurements:**

Project staff and IID will measure the amount of applied water, surface runoff, and hay (or crop) yield. Project staff will take the necessary measurements to evaluate irrigation efficiency, water use efficiency, hay yield and quality (crude protein, acid detergent fiber, and neutral detergent fiber). The following parameters will be determined:

- Average depth of applied water
- Soil moisture content prior to and after each irrigation event
- Water table depth prior to and after each irrigation event
- Water table salinity and chloride concentration prior to and after each irrigation event
- Surface runoff water during and after irrigation events
- Soil salinity (twice a year)
- Soil chloride content (twice a year)
- Average yield after each cutting (or crop harvest)
- Hay quality (twice a year)

- Drainage water salinity and chloride content
- Estimate of drainage outflow

To account for soil spatial variability one set of borders in this treatment will be irrigated similarly to treatment A.

#### **Location 2 sudangrass (fields A & B)**

**Field A:** Same as field A in Location 1 sudangrass

##### **Measurements:**

Same as field A in Location 1 sudangrass

**Field B:** Same as field B in Location 1 sudangrass

##### **Measurements:**

Same as field B in Location 1 sudangrass

### **3.4 All alfalfa and sudangrass locations (Fields A and B)**

We will evaluate the irrigation efficiency of each field by taking advance, runoff, and flow rate measurements and total applied water and surface runoff water. Soil moisture distribution in at least two borders will be evaluated using a neutron probe or a similar device. A total of 16 9-ft neutron probe (or a similar device) access tubes will be installed in each field to characterize soil moisture distribution in the field. Moisture measurements will be taken at depths of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 6.0, 7.0, 8.0, and 9.0 ft prior to and approximately two days following each irrigation event. Gravimetric soil moisture samples will be taken in the 0-6" depth range. Evapotranspiration estimates during and two days following irrigations will be obtained from the closest CIMIS weather station and will be added to the difference in soil moisture prior to and following each irrigation event. Soil samples will be taken twice a year from each field at various depths (0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 6.0 ft) to evaluate soil salinity before the first cut and throughout the project. A total of 16 10-ft observation wells will be installed in each field next to access tube locations. Water samples from each well will be taken for chemical analysis of the shallow groundwater throughout the project.

Alfalfa or sudangrass yield will be determined for each cutting (bales in the field as well as small sections of alfalfa or sudangrass yield next to each access tube location). Statistical methods of evaluation will involve the use of ANOVA and time series analysis software.

Advance time will be recorded every 100 ft along the selected borders. The commonly used Kostikov and modified Kostikov equations

$$z = kt^a \quad \text{and} \quad (1)$$

$$z = kt^a + ct, \quad \text{respectively,} \quad (2)$$

where  $z$  is the depth of water infiltrated,  $t$  is the intake opportunity time,  $k$  and  $a$  are empirical

constants, and  $c$  is the steady infiltration rate, and other infiltration function will be used as needed to simulate border irrigation performance in a volume-balance model. Infiltration function parameters  $k$  and  $a$  will be obtained for each irrigation and each border from advance data using a power advance function of the form

$$X = pt^r \quad (3)$$

where  $X$  is the advance distance (m),  $t$  is the advance time (min), and  $p$  and  $r$  are fitted parameters. The above power advance function will be used to predict the infiltration function parameters  $k$  and  $a$  of the Kostiaikov equation using the two-point method. Simulated and field-measured irrigation performance characteristics of border irrigation (application efficiency, distribution uniformity, surface runoff, deep percolation, and depth infiltrated) will be evaluated for all irrigations using spatially averaged and temporally variable infiltration characteristics.

#### 4 Surface Runoff Reduction Method

Irrigation scheduling can be based on a relatively simple technique that predicts the cutoff time necessary to minimize runoff and to improve water use efficiency. While the method is applicable for all soils, it works best in heavy clay soils. The method is a combination of a volume balance model and a two-point measurement method.

The main objective in heavy clay soils is to have enough water to fill cracks with little or no runoff. The cutoff time can be calculated for a given border using a volume balance model where the total volume of water applied equals the surface storage and the subsurface storage. At any time ( $t_x$ ) the volume applied,  $V$ , is

$$V = Q * t_x$$

Where  $Q$  is the inflow rate in cubic feet per second (cfs) and  $t_x$  is the time in minutes. The surface storage ( $SY$ ) equals the product of the average depth of water and the area covered by water

$$SY = \sigma_y * d * w * l_x$$

where  $\sigma_y$  is the surface shape factor (0.6-0.8),  $d$  is the depth of water at the water inlet in feet,  $w$  is the width of border in feet, and  $l_x$  is the advance distance at time  $t_x$ .

The subsurface storage ( $SZ$ ) equals the product of the average depth stored and the area covered by water. Earlier in the irrigation, soil cracks dominate the process of infiltration and the volume of the subsurface storage is essentially the volume of cracks. Thus,

$$SZ = z * w * l_x$$

where z is the average depth stored below the soil surface in feet, and w and  $l_x$  are as defined earlier. The total volume, V, is the sum of the surface storage and subsurface storage:

$$V = SY + SZ$$

The average depth stored below the surface can be found at any time,  $t_x$ ,

$$Q * t_x = (\sigma_y * d * w * l_x) + (z * w * l_x)$$

$$z = \frac{(Q * t_x - \sigma_y * d * w * l_x)}{(w * l_x)}$$

when z is known, the time of cutoff,  $t_{co}$ , can be determined to minimize runoff. The total volume applied ( $Q * t_{co}$ ) equals to the volume stored:

$$Q * t_{co} = w * L * z$$

$$t_{co} = \frac{(w * L * z)}{Q}$$

where L is the total length of the border.

The following information is needed to determine cutoff time:

- 1- Border length and width in feet.
- 2- Average flow rate in cfs.
- 3- Depth of the water at the inlet (or soil roughness).
- 4- One or two points of water advance with time along the border.

**5 BUDGET:** Two alfalfa locations (4 fields) and two sudangrass locations (4 fields)

	1997* (Nov. 16 - Dec. 31)	1998	1999	2000	Total
<b>Salaries</b>					
(2 SRA step I: \$27,468/yr per FTE, 2 Lab Asst step II: \$21,660/yr per FTE)	\$12,282	\$98,256	\$103,169	\$108,327	\$322,034
Benefits (28 % of salary)	\$3,439	\$27,512	\$28,887	\$30,332	\$90,170
Subtotal	\$15,721	\$125,768	\$132,056	\$138,659	\$412,204
<b>Equipment</b>					
Soil augers		\$500	\$500		\$1,000
Computer and printer		\$2,500			\$2,500
Salinity & Ion electrodes		\$2,600			\$2,600
Neutron probe/soil moisture measuring devices		\$4,500			\$4,500
2 County/University trucks		\$13,800	\$14,490	\$15,215	\$43,505
Subtotal		\$23,900	\$14,990	\$15,215	\$54,105
<b>Supplies</b>					
Irrigation & soil sampling supplies		\$3,500	\$2,500	\$2,500	\$8,500
Reagents and chemical supplies		\$2,400	\$2,600	\$2,600	\$7,600
Radiation use authorizations and training on Neutron probe		\$1,400	\$1,500	\$1,600	\$4,500
Subtotal		\$7,300	\$6,600	\$6,700	\$20,600
<b>Travel</b>					
To present findings and for travel to/from UCD.		\$1,200	\$1,300	\$1,400	\$3,900
<b>Total direct cost</b>	\$15,721	\$158,168	\$154,946	\$161,974	\$490,809
<b>Indirect cost (10% to all except equipment)</b>	\$1,572	\$13,427	\$13,996	\$14,676	\$43,671
<b>Total</b>	\$17,293	\$171,595	\$168,942	\$176,650	\$534,480